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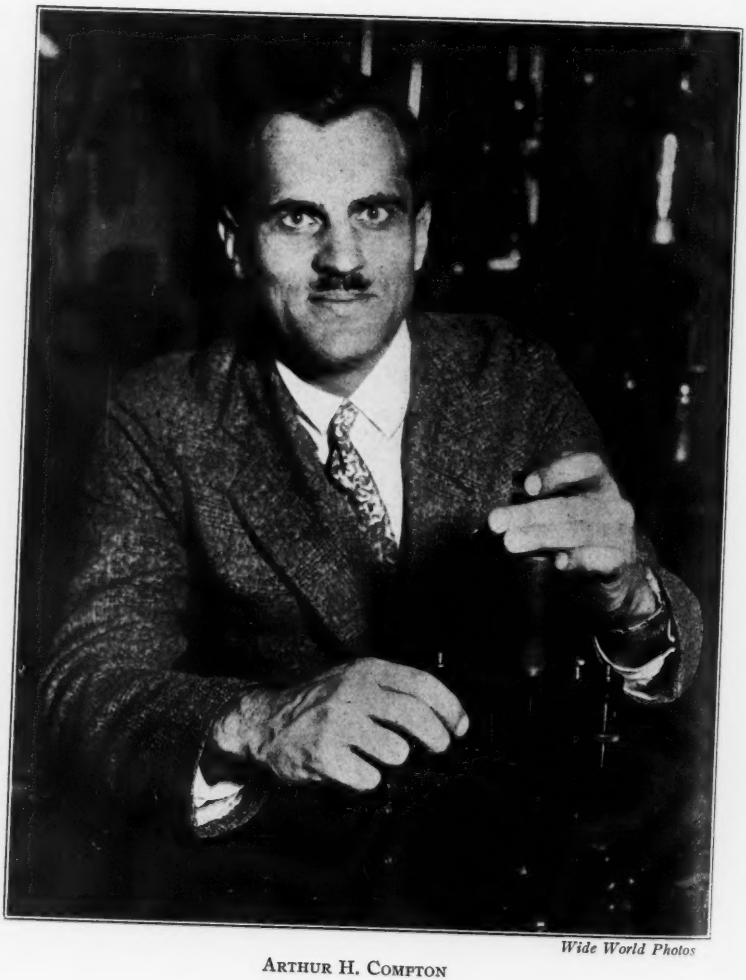

Wide World Photos

ARTHUR H. COMPTON

EDITOR'S OUTLOOK

Arthur Holly Compton
1892–

THE physicist whose portrait is the frontispiece of this number of the JOURNAL, and whose article, "What Is Light?" we are privileged to publish also in this issue (pp. 2769–87) has covered as it were with seven-league boots much of an otherwise uncharted area of X-ray radiation. He entered, September 10th last, upon his thirty-ninth year, an acknowledged authority in this field, with an extensive list of contributions to the knowledge of it already to his credit. In 1927 the American Academy of Arts and Sciences recognized his work with the Rumford Medal and in the same year he shared with C. T. R. Wilson the Nobel award in physics.

Dr. Compton is a native of Wooster, Ohio, and received his undergraduate education at the College of Wooster, at which his father, Elias Compton, was a professor of philosophy. Aeronautics engaged his youthful bent for experiment, and before he received his B.S. from Wooster in 1913, he had also worked out in the college observatory a new method for demonstrating the earth's rotation which was suggested to him by the movements of endolymph in the semi-circular canals of the ear.

The years 1913–16 were spent at Princeton on a Porter Ogden Jacobus fellowship, out of which he received his doctor's degree and produced a dissertation on a theory of X-ray reflection from crystals as a means of studying the arrangement of electrons and atoms. Since that time concentration in the line of X-ray research has resulted in his determination of the index of refraction of X-rays, the absolute measurement of wave-lengths with ruled gratings, the discovery of the complete polarization of the rays, measurement of the intensity of X-rays reflected from crystals, the theory of the relation of scattered X-rays and recoil electrons to the quantum theory and discovery of the changed wave-length of scattered rays. The phase of his research which attracted the attention of the Swedish Academy and determined the selection for the Nobel award of 1927 was the discovery of the "Compton effect," the change of X-ray wave-lengths noted after reflection from crystals. In the past three years his investigations have resulted in the development of a method for determining the arrangement of the protons and electrons within an atom.

Dr. Compton holds the post of professor of physics at the Ryerson Physical Laboratory of the University of Chicago. His previous teaching experience included a brief period shortly after his departure from Princeton as instructor at the University of Minnesota and, after an interim of industrial research, a charge as head of the department of physics at Washington University. He has held his present appointment since 1923.

A year of graduate research at Cambridge, 1919–20, and another in

India, 1926–27, on a John Simon Guggenheim fellowship, during which time he acted as special lecturer at Punjab University, Lahore, have served to establish valuable foreign contacts.

Dr. Compton has acted as president of the National Research Council's Committee on X-Rays and Radioactivity. He is an associate editor of the *Physical Review*, a fellow of the American Physical Society and a member of the American Optical Society, the American Association for the Advancement of Science, and the American Philosophical Society, and foreign member of the Reale Accademia dei Lincei, Rome.

The JOURNAL OF CHEMICAL EDUCATION *acknowledges with gratitude the courtesy of W. V. Morgenstern, Department of Public Relations, The University of Chicago, for the material upon which the above biographical sketch is based.*

A New Tool in Instruction

THE moving picture is already a recognized tool in instruction. So far as chemical education is concerned, however, it is still at the threshold of its usefulness. Many excellent films on chemical subjects are available to schools at nominal or moderate rental costs, and many teachers make use of them. For the most part, these films have not, however, been prepared primarily for classroom use. Most of them bear the same relationship to the truly essential portions of the course that books and articles of a popular nature bear to a good textbook. In short, they are chiefly supplementary, inspirational, and generally informative. This is written in no spirit of disparagement. Such films have a legitimate place in the classroom and we shall always have need of them. But until we progress beyond this stage and begin to produce films planned by people experienced in the classroom to meet specific classroom needs, we shall have left a potentially valuable tool virtually unused.

It is a mistake to think that the moving picture, either silent or speaking, is in any sense a substitute for the teacher. It would be just as sensible to argue that a hammer, a saw, and a plane constitute some sort of substitute for a carpenter. Nor can anything significant be accomplished by deciding to use films because visual education seems like "a good idea" or because one aspires to be "progressive," and then casting about to find where films may be jimmied into the course. The films of most permanent and substantial value will be those which are devised with one clear aim in view—to enable the teacher to accomplish something which he has recognized as desirable but which he has never been able to accomplish with the other means at his disposal. It would be a deplorable waste of time and money to take a standard textbook of the better sort, to base a series of scenarios upon its chapters or major sections, and then to proceed to film the result.

We have already pointed out in these columns that the animated diagram has unique possibilities as a medium of instruction. It has been very cleverly handled in some portions of "The Production of a Photographic Image," produced by Eastman—to mention but one example. It seems admirably adapted to the presentation of ideas on atomic structure, on the crystal diffraction of X-rays, on the operation of cells and storage batteries, and on dynamic equilibrium. Any teacher who makes good use of his blackboard can suggest numerous additions to this random selection. The classroom blackboard is, by reason of its limitations, the place above all others where good ideas for animated diagrams are born.

The advent of the talking picture opens up a new field of possibilities. Unfortunately very few schools, or universities either for that matter, are as yet equipped for the projection of sound films, nor are many such films available. Doubtless time will change all this, however. We can all remember when educational institutions had no silent film projectors. Eventually selected lectures by famous scientists will be available to many schools which could never hope to invite these lecturers in person. A beginning in the production of such films has been made by The Chemical Foundation through the courtesy and coöperation of the Radio Corporation of America. The sound picture, "Cosmic Ray," by Dr. Millikan, had its first public showing on Friday evening, November the seventh, at The Johns Hopkins University,* and was the subject of much favorable comment.

The contemporary value of such films is great and will increase with the multiplication of facilities for their projection. But their contemporary value is not to be compared with their future historical value. What would we not give to have in our film libraries of today sound pictures in which Faraday, Davy, Pasteur, and other immortals described their chief contributions to science! If we seize the opportunity now opening to us, future generations of scientists will arise to call us blessed.

The Index

THE final number of the year includes, as usual, the Annual Index. From year to year the format and general arrangement of the index have been modified somewhat to keep pace with the growth of the JOURNAL and to conform with criticisms and suggestions received from readers. This year's volume is no exception.

In preparing the index the staff has been guided to a considerable extent by its own experience, for it must make constant reference to earlier volumes. However, the members of the staff are aware that their own

* See pp. 3008–9 of this issue for an account of the occasion on which this picture was first presented.

needs in the matter of an index may differ somewhat from those of the general reader, and they have tried to keep the reader's viewpoint in mind throughout. For fear that the principles followed may not be immediately obvious to the occasional searcher, a detailed explanation has been prepared and is inserted at the beginning of the index.

While we are not yet satisfied that the general form and arrangement are the best possible, we *can* say with assurance that the index is complete. If first trial does not discover the item sought, reference to the explanation should lead to success. In general, it will be possible to find any article or abstract concerning which the searcher has any one of the following facts:

(1) the name of the author or one of the authors;
(2) the title of the article;
(3) one or more of the significant words in the title of the article;
(4) the general topic of which the article treats.

Books reviewed and scientific news notes have not been so thoroughly cross-indexed as articles and abstracts, but most of them appear in the index several times.

We shall be glad, as always, to receive suggestions and criticisms leading to further improvements in the index. The earlier in the year such suggestions are received, the more helpful they will be, for index-making is an all-year task. With minor exceptions no alteration in plan is possible after the year is well under way.

The Teaching "Profession"

IN A NATION where undertakers are morticians and real estate agents are realtors, it is to be expected that teachers will aspire to be known as members of a profession. We must confess that we are deeply in sympathy with that aspiration. But let us, nevertheless, examine the facts.

What constitutes a profession? Unfortunately, there seems to be no clear-cut definition. That group which is most frequently cited as typifying and embodying the principal characteristics of a profession is, no doubt, the medical fraternity. With this as a point of departure let us make note of some of the earmarks which seem to distinguish a profession.

First, we may say that a profession has a tradition and literature. It has also a strict and well-defined code of ethics. Furthermore, not only are its activities such as to appeal to persons of superior intelligence and education, but also such as to demand these qualifications for a reasonable degree of success. The financial rewards, although not necessarily glitteringly attractive, are, for the moderately successful, sufficient to sustain self-respect. The members of the profession are, for the most part,

able to maintain a certain independence of attitude and thought and are not readily susceptible to financial or other pressure in matters of principle. The profession is, generally speaking, considered worthy of constituting a life vocation; it is not a stepping-stone to something else. By reason of these characteristics and possibly of others which we have neglected to mention, the profession for the most part enjoys a respected and honored position in the community and membership in it confers a certain degree of prestige apart from that which the individual is able to command in his own right.

Without attempting to apply these touchstones individually and in detail to the vocation of teaching, let us ask ourselves what is wrong with teaching as a vocation. To begin with, it is underpaid. This is not necessarily to say that all teachers are underpaid. Some few teachers are adequately paid for competent work. Entirely too many are adequately paid or overpaid for the grade of work which they do. As a vocation, however, teaching is underpaid. Remuneration *should not* be, and is not always, the primary consideration in choosing a career, but the hard, cold fact remains that brains and ability do tend to gravitate toward good economic markets.

Nevertheless, it is a mistake to think that the situation can be improved merely by raising salary scales. The competent teacher—he who should, and often does, become a "career man," to borrow a phrase from the diplomatic service—suffers both from unworthy and from transient competition. He can be protected from such competition only by higher teaching requirements. Scholastic standards for teachers have already risen in most states, and there is every indication that they will, praise Allah, rise still higher. But even this is not sufficient. Is it too much to ask that the trainers of youth should come from among those who have maintained a standing in the upper quarters of their respective classes throughout their general education? Good scholarship does not, it is true, guarantee good teaching, but poor scholarship almost invariably guarantees poor teaching. It is only by raising requirements to the point where teaching becomes an inconveniently difficult route to other occupations and an impossible refuge for the half-educated of no particular talents or training that we shall make teaching safe for teachers.

There remains the question of security of tenure—one which can be solved only through a greater sense of solidarity and a greater vocational consciousness among teachers. But this question like the question of salary is a double-bitted one. Teachers will do their vocation more harm than good if they succeed in securing guarantees of tenure which do not provide for the prompt dismissal of incompetents.

Here we shall let the subject rest for the present. In conclusion, ladies and gentlemen, we give you: "The Future Profession of Teaching."

THE DIALYZER

(*For questions* 1–3 *see* pp. 2769–87.)

1. Briefly characterize the range of electromagnetic radiations.
2. What is a photon?
3. What is light?

(*For questions* 4–6 *see* pp. 2788–2807.)

4. What is gypsum? Anhydrite? How do you account for the occurrence of both in nature?
5. Where are the chief gypsum deposits in the United States?
6. Outline briefly the essential features of the gypsum industry.

(*For questions* 7–11 *see* pp. 2808–28.)

7. Who discovered nitrogen?
8. What experimenter and philosopher of the 19th century laid the foundations of our present-day colloidal chemistry?
9. What Scottish chemist advanced a theory of structural chemistry which was prior to and an advancement on that of Kekulé?
10. Where and by whom was the use of the hot blast introduced in the manufacture of pig iron?
11. By what process is potassium cyanide made commercially today? To whom are we indebted for it?

(*For questions* 12–13 *see* pp. 2829–49.)

12. What is diatomaceous earth?
13. Of what importance is diatomaceous earth in chemical industry?

(*For questions* 14–15 *see* pp. 2850–62.)

14. Explain the mechanism whereby the human body attempts to preserve its normal reaction.
15. What is acidosis? Alkalosis? To what abnormal reactions in the body are these conditions due?

16. The works of what 13th century French poet are of considerable importance in a study of the history of science? (pp. 2863–74.)
17. Who was Thomas Messinger Drown? What influence did he exert on the technical education of the United States during the latter part of the 19th century? (pp. 2875–86.)
18. Into what three major classes may homogeneous catalysis be divided? Give an example of each. (pp. 2887–2903.)
19. Given the problem of constructing tetrahedra models of the dextro-, levo-, and meso-tartaric acids. Outline the method of procedure you would follow. (pp. 2904–12.)
20. What films are available for use in chemistry classes? Under what conditions may they be obtained? (pp. 2916–27.)

(*For questions* 21–22 *see* pp. 2928–45.)

21. What business was transacted at the Cincinnati meeting by the Division of Chemical Education?
22. What steps have been taken to secure the coöperation of publishers and chemistry teachers in the improvement of chemistry label books?

23. How many articles were published in the JOURNAL OF CHEMICAL EDUCATION during the year 1930? (pp. 3027–3112.)

WHAT IS LIGHT?*

ARTHUR H. COMPTON, RYERSON LABORATORY OF PHYSICS, UNIVERSITY OF CHICAGO, CHICAGO, ILLINOIS

The age-old question—what is light?—is one which it is probably as difficult to give a really satisfactory answer to, as it was in the time when the Greeks talked about the "Shafts of Apollo." Doubtless we know much, much more about light than did the Greeks, yet we also realize more fully how much there is yet to be known with reference to light than did the Greeks.

During the last three centuries, from the period of the conceptions of Galileo, Newton, and Huyghens, the ideas of the nature of light have developed into rather definite form. We are familiar with the corpuscular theory which Newton defended—the conception that the sun shot out little particles which were perhaps reflected from objects into the eye. Huyghens, a contemporary, insisted that light was waves. Some argument supported the corpuscular idea; other data seemed to support the wave theory.

At about the beginning of the nineteenth century, however, the experiments of Fresnel and Young, combined with the brilliant theoretical development by Fresnel, gave what was convincing proof, in the author's judgment, that light has the characteristics of waves. Fresnel had tried to account for these waves in terms of the vibrations of an elastic ether. Maxwell later proposed his electromagnetic theory of light in which the elastic ether was displaced by the electromagnetic idea. The work of Hertz and Marconi in the radio field has given us an insight into the nature of electrical rays. We have also become familiar with X-rays, gamma rays, and the different types of electromagnetic radiation. Now we speak of light in terms of wave-lengths and frequency, these now being household words when we "tune in" a broadcasting station. The idea that light could have any other characteristics than those of waves does not ordinarily occur to the layman.

Within the last twenty-five years, however, physicists have observed an increasingly large group of phenomena, chiefly of an electrical character, which have been difficult to interpret on the basis of the wave characteristics of light. These phenomena have been explained on the assumption that light has the characteristics of particles. So we now have two alternative pictures of light, one which describes light in terms of waves, and the other in terms of particles.

Many times the author has been asked, "What does it matter whether light consists of waves or particles?" This is perhaps a little difficult to answer at present. Had Fresnel been asked what was the importance of his discovery that light consisted of waves, he might have replied that

* Presented before the Physical Science Section of the Tenth Ohio State Educational Conference, April 4, 1930.

it was difficult to see that it had any practical significance. Of course it had certain bearing on the design of a microscope. A microscope must have a certain definite resolving power if light consists of waves. The real significance of the wave theory came when Maxwell developed his electromagnetic theory of radiation, thereby accomplishing the final step of the classical electrodynamics. The establishment by Fresnel and Young of the wave theory of light, then, may really be considered as an essential step in the development of electro-dynamics, and therefore a basic step for the whole electrical industry. The chief values of scientific discoveries, in my opinion, are not the practical aspects of the discoveries, but the increase of our knowledge and the consequent control of the phenomena around us.

It was Millikan who recently said, "Man's greatest discovery of all time is that he can rely upon the world in which he lives." Newton expressed the same thought when, in the words of Alfred Noyes, he described as the task of science—

> "Through this wilderness of time and space and false appearances,
> To make the path straight from effect to cause"—

thus implying that every effect has a definite cause; that with a definite set of conditions, a definite result may be expected to come from it. The generally accepted postulate of all scientific endeavor is that certain things always happen in certain ways. One of the results of the fact that certain things have dual characteristics, particles and waves, is that we cannot rely upon the world with too great definiteness. The results can only be described with some degree of probability, not certainty. It was in the study of light that we first obtained definite evidence of these dual characteristics of wave and particle—wavicle, as some one humorously called it. I wish to present hastily some of the evidence which we have that light consists of particles and try to show briefly how this bears upon our fundamental conceptions of the nature of light.

Varieties of Light

Light to the physicist is not merely the radiation from the lamp, sun, or moon which affects the eye. Light to him includes a vast range of radiations similar to and including the rays which affect the eye, the radiations differing from each other in that characteristic familiarly known as color, or wave-length, or frequency.

On one end of this scale of radiation are the rays we know as radio rays. But in order to interpret what we mean by radio rays, let us recall a familiar experiment with sound which in form is closely analogous to rays. When a tuning fork is struck we hear its ring. In looking for the source of the sound we find that the fork prongs are vibrating as is evidenced

when touched with the finger. On examining the vibration, we find the fork is vibrating with the same number of vibrations per second as are the sound waves coming from the fork. A second tuning fork of the same pitch receives the vibrations and after the first fork has died down, the humming of the second one is heard.

A similar phenomenon may be observed with the use of a small radio tube (receiving) and a short-wave transmitter. The oscillator of the transmitter corresponds to the hammer which caused the first tuning fork to vibrate; the resulting oscillations correspond to the vibrations of the tuning fork. Just as the sound from the tuning fork may be magnified by mounting it on a wooden block, so may the electric oscillations from the transmitter be amplified by connecting it to two copper rods or antennae, thus causing the radio rays to spread out into space with much greater vigor. When a second pair of copper rods jointed at the middle through a lamp are brought parallel to the oscillator rods, the lamp filament in the second set of rods glows; in the same way, the sound waves from the sound oscillator set up oscillations in the ear drum, which are interpreted as sound. The waves from the radio oscillator are polarized waves, that is, the vibrations are in the plane of the transmitting rods. If the receiving set of rods is in this plane the lamp filament glows; if out of the plane the filament does not glow. These rods must be tuned to the oscillator—that is, the length of the rods must bear a certain relationship to the wave-length of the oscillator. When the receiving rods are moved closer to the transmission rods the lamp will burn more brightly. Radio waves then are broadcast from the transmitter in the same way that sound waves are broadcast from the tuning fork.

The waves coming from an electrical oscillator are of the same frequency as the electrical oscillations produced in the apparatus. By means of suitable devices we can measure the frequency of the oscillations and also the frequency of the waves being transmitted. When, however, we measure the frequency of a beam of light and find it to be 10^{15} times per second, and then look for the oscillations 10^{15} times per second, we find it very difficult to identify such an oscillation. The old theory of the atom had no picture of an electron oscillating with the frequency of the wave which was emitted. It required a new kind of mechanics in the hands of Heisenberg, Schrödinger, and others, to show that there was in the atom some oscillator vibrating with the frequency of the wave which was emitted. This then is one of the contributions of the new mechanics as contrasted with the older form of the quantum theory.

Heat rays are also familiar to us. If a person is near a glowing stove in a cold room, the side of the body nearest the stove will receive the direct rays and become warmer than the side farthest away. These rays are of the same character as the wireless waves, the longer heat waves

overlapping the wireless waves, and the shorter heat waves including those of ordinary visible light.

The spectrum of visible light may be produced on a screen by projecting the light from a carbon arc through a quartz lens and quartz prism. The visible rays are also heat rays as they are the ones radiated by hot bodies, such as the incandescent lamp.

Is there a ray beyond the violet end of the visible spectrum? If visible light is projected on a white card, the upper half of which is coated with platinum-barium-cyanide, the violet portion of the spectrum is seen on the uncoated part of the white paper and the ultra-violet is seen as a brilliant green on the coated portion of the card. These are the well-known ultra-violet rays about which we have heard so much as summer sunshine in the prevention of rickets and similar diseases. The function of the fluorescent wave screen is to change the wave-length of the ultra-violet rays, so that they are of a length to which the eye is sensitive.

How far may we go into the region of the ultra-violet and still find radiation present? Glass absorbs these rays, and even though air is more transparent than glass, it also begins to absorb the shorter rays. But at still shorter wave-lengths the rays are again less readily absorbed as we approach the region of X-rays. The X-rays can also be shown by projection on the platinum-barium-cyanide screen. So from the ultra-violet we can go on still further beyond the visible spectrum to the region of the X-rays. Figure 1 is a diagram of an X-ray tube. These rays are produced, not like the light from a carbon arc, but more on the order of the rat-a-tat of a steel target when bombarded by a flow of bullets from a rapid-fire gun. In the X-ray tube electrons (bullets) are shot at a high speed by a high-tension transformer (50,000 to 200,000 volts) from the cathode (negative electrode) against the target (anode or positive electrode), and there the striking electrons give rise to the X-rays—a type of radiation similar to ultra-violet light.

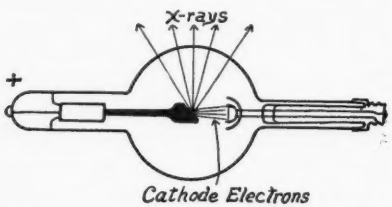

FIGURE 1.—COOLIDGE X-RAY TUBE

Overlapping and beyond the X-rays are the gamma rays from radium, which are much more penetrating. Whereas X-rays may be half absorbed in an inch of water, the gamma rays are only half absorbed in a foot of water.

Beyond the gamma rays there exists a highly penetrating radiation, especially prominent at high altitudes and supposed to have some source outside the earth. These "cosmic rays" will penetrate ten or twenty feet of water before they are half absorbed.

In Figure 2 we see graphically how these different rays are related to each other. At the extreme left, I have arbitrarily started the spectrum with the long trans-Atlantic radio signals of perhaps ten miles in length. The waves continue in an unbroken spectrum on through waves of 0.1 mm., rays recently studied at Cleveland by the late Dr. Nichols and Mr. Tear. The heat rays which have been observed from about 0.03 cm. to 0.00003 cm., including the whole of the visible region, overlap these electric waves. The heat rays, in turn, are overlapped by the ultra-violet rays produced by electric discharges; and these reach well into the region described as X-rays. Beyond these are in turn the gamma rays and the cosmic rays. Thus over a range of wave-lengths of from 2×10^{-13} cm. to 2×10^{6} cm. there is found to be a continuous spectrum of radiations. If I should magnify this whole scale until the wave of a cosmic ray has a length equal to the thickness of a post card, then the longest wireless wave would extend from the earth to the nearest fixed star. It is to this vast range of radiations, of which visible light is a very small although important part, the physicist refers when he speaks of light.

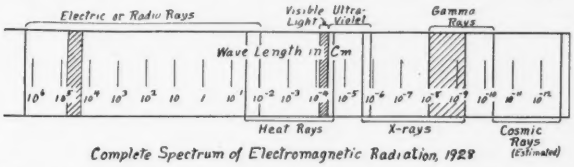

FIGURE 2.—COMPLETE SPECTRUM OF ELECTROMAGNETIC RADIATION ON A LOGARITHMIC SCALE

Does Light Consist of Waves?

There are many ways in which light acts like a wave in an elastic medium. Such elastic waves move with a speed which is the same for all wave-lengths and all intensities, just as does light. Waves, like light rays, can be reflected and refracted. The polarization of light is a property characteristic of the transverse waves in an elastic solid. It is true that if one examines the constancy of the speed of light in detail, difficulties arise; for it is found that its speed is the same relative to an observer no matter how fast the observer is going. This would not be true if light were a wave in an ordinary elastic medium. Maxwell's identification of light as electromagnetic waves, however, removes this difficulty.

The crucial test for the existence of waves, however, has always been that of diffraction and interference. When a pebble is dropped into a quiet pool of water the ripples spread out in all directions. If two or three pebbles are dropped in at the same time, in some places the crests of one set of ripples fall on the crests of another and an intense ripple re-

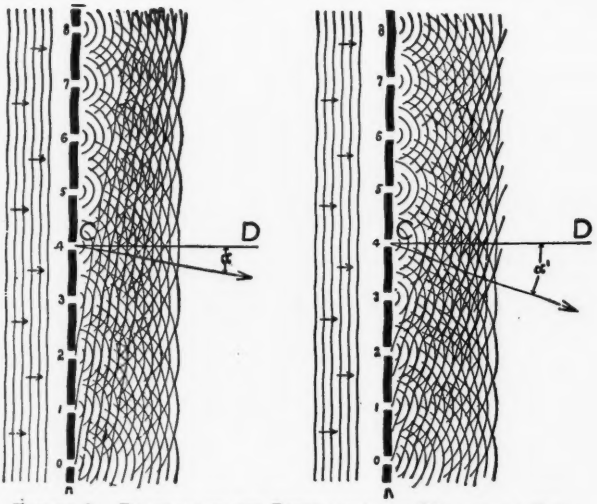

FIGURE 3.—DIAGRAM OF THE DIFFRACTION OF WAVES BY A GRID

sults; in other places, the crest of one falls on the trough of the other, thereby neutralizing one another.

Suppose we had a whole row of pebbles falling into the water at the same time, then we would get a set of ripples coming out from different points all at the same time. The effect would be like that shown in Figure 3, in which we imagine a series of waves passing through the successive openings in a grid. We would get sets of waves going straight ahead, perpendicular to the line through the places where the pebbles had dropped, represented in the diagram by the openings in the grid. But in addition to this set of waves going straight ahead we should get the wave which is merging from one opening, combining with the first one from the next opening, the second from the next, the third from the next, and so on,

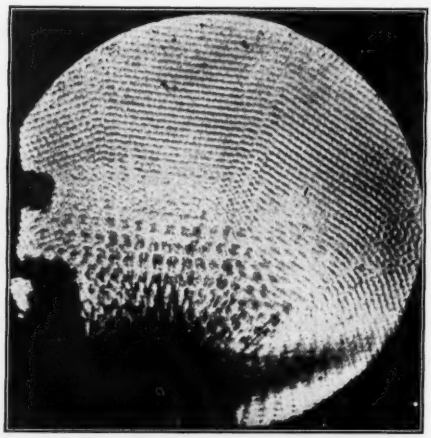

FIGURE 4.—PHOTOGRAPH OF MERCURY RIPPLES DIFFRACTED BY A GRID

forming a new wave-front inclined at a definite angle α to the first. The angle between these two waves, as indicated on the diagram, is determined by the distance between the successive waves—the wave-length—and by the successive openings in the grid. The figure at the right shows how the wave emerging from one opening may combine with the second wave from an adjacent opening, the fourth from the second adjacent opening, and so on, and form a wave-front which advances at a larger angle α'.

It is easy enough to draw such a picture but the question is, do such wave movements actually occur? Figure 4 is a photograph of ripples on the surface of mercury made by a set of little pins oscillated up and down on the mercury, so that each pin started a set of ripples. One group of waves combined to form a wave-front going out perpendicularly. But

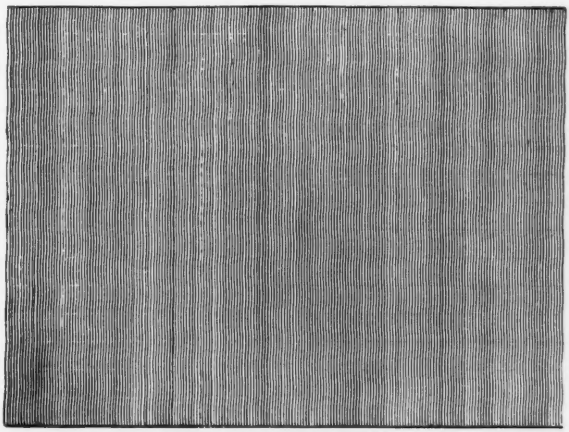

FIGURE 5.—A PATTERN OF 200 REGULARLY SPACED LINES

on either side of the central beam, two beams formed where the paths from successive openings in the grid differed by just one wave-length. Out of a larger angle the second order of the diffracted beams appeared.

If we were unable to see the individual waves, but could see the direction in which the ripples were proceeding, and knew that the ripples had started from a series of points, not only could we see from the peculiar way in which these ripples had divided themselves that they must consist of waves, but we could also determine what the wave-length of the ripples must be to form these particular angles between themselves. This affords a means of getting at the characteristics of these waves.

A similar experiment may be performed using a beam of light instead of a beam of mercury ripples. In Figure 5 is shown a set of some 200 parallel lines. These were photographed giving a lantern slide grid.

In the upper left section of Figure 6 is a photograph of a beam of light from a projection lantern. When the beam is projected through a lantern grid about one hundred lines per inch, the beam is split into three as shown in the middle left section of Figure 6—a bright one in the center and a diffracted ray on either side. It is the same as in the case of the mercury ripples passing the grid.

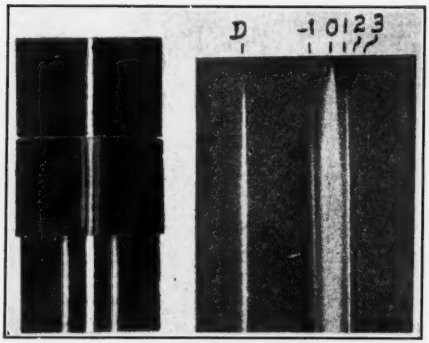

FIGURE 6.—DIFFRACTION PATTERNS
Left—diffraction of light.
Right—diffraction of X-rays.

If this is really a diffraction phenomenon, then a grid with the lines closer together should give a correspondingly greater separation of the diffraction images. In the lower left section of Figure 6 is the result with a grid having three hundred lines to the inch. In the actual experiment, the outer edges of the lines are red, and the inner edges greenish. This means that red light is of the longer wave-length. From the projection it is also possible for us to measure the wave-length—the ratio of the wave-length of the light to the distance between the grid lines is the same as the ratio of the distance between the central and diffracted image to the distance from lantern to screen. The actual calculation gives light a wave-length of about one-fifty thousandth of an inch, the red somewhat longer and the green light somewhat shorter. This gives us direct evidence that light has the characteristics of waves.

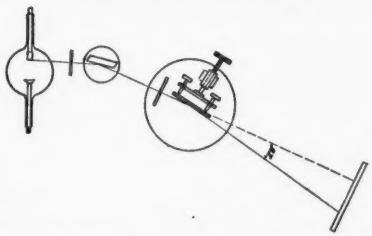

FIGURE 7.—APPARATUS FOR DIFFRACTING X-RAYS FROM A RULED REFLECTION GRATING

But, you ask, how about some of these other forms of electric radiation? Precisely similar experiments can be done with X-rays. A diagrammatic representation of how it is done is given in Figure 7. Instead of the projection lantern we have an X-ray tube and a pair of slits. The lantern grid is replaced by a polished mirror having fifty ruled lines to the millimeter. The photograph of the result is shown in Figure 6 (right). When the mirror is withdrawn we get only the line *D;* and with the mirror in

position we obtain the bright central reflected image *O* with companions on either side, the same as with light (Figure 6, left). Thus X-rays also have the characteristics of waves. All of these radiations from X-rays to radio rays can be polarized, reflected, and refracted. It was not necessary to describe these characteristics in the detail that I have, but it seemed worthwhile to call attention to the fact that, though we have the information now that light consists of particles, we still believe and say that it has the characteristics of waves.

Does Light Also Consist of Particles?

Let us then consider the question as to the particle characteristics of light rays. Let me refer to radiation from hot bodies. One way of describing the phenomenon is to call attention to the fact that the light from a hot body changes in color as the temperature rises—it first becomes a dull red, then a bright orange, then yellow, and finally white.

According to classical mechanics, all different wave-lengths have in them about the same amount of energy. No matter what the frequency of an oscillator is, when in temperature equilibrium with any other oscillator, it has the same energy as the second oscillator. The color should be independent of the temperature; heat, according to this theory, only changes its intensity.

This theory has been proved to be contrary to experiment. In 1900 Planck published the results of a long study of the radiation of heat and light from a hot body. This difficult theoretical study, which has stood the test of time, showed that if a body when heated is to become first red hot, then yellow, and then white, the oscillators in it which give out the radiation must not radiate continuously as the electromagnetic theory demands; rather they must suddenly radiate little portions of energy. The amount of energy in each portion must also be proportional to the frequency. Thus only at high temperatures will the blue light of high frequency be emitted; for only at high temperatures will the oscillators have enough energy to emit a whole unit of high-frequency radiation. Hence, as the temperature increases, light of shorter wave-lengths is emitted in greater and greater proportions and the color moves from the red toward the yellow and the blue.

This argument, however, was couched in such mathematical terms that it appealed only to theoretical physicists; and, since the majority of physicists were experimental rather than theoretical, the idea did not make much headway. One theoretical physicist who did see much in it of value was Einstein. He saw in it the picture of radiation being emitted as discrete units of energy rather than as waves; and that each particle of radiation has an amount of energy determined by the frequency of the vibration and equal to $h\nu$.

The strongest evidence Einstein had for this picture was found in the photoelectric effect. In order to understand this effect it is necessary to trace the motion of electrons.

Some three years ago I happened to be studying cosmic rays up in the Himalaya Mountains. Just beyond the mountain were the plains of India, and on my side the Vale of Kashmir. It was most interesting to observe that as the wind came from the southwest, it carried the damp air from the warm plains up over the mountains, where rising, the expanding air was cooled and a cloud would form. Then as the air came down on my side of the range, the cloud would come down, be compressed again by the thicker air layer in the lower levels, and the cloud would evaporate.

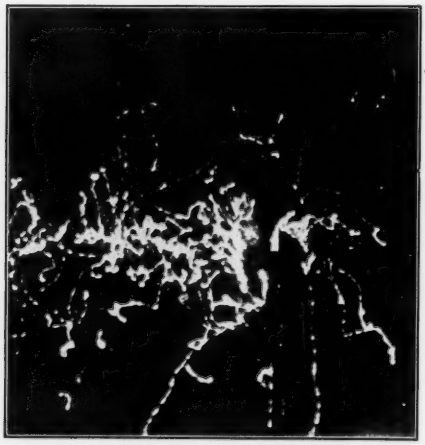

FIGURE 8.—PHOTOGRAPHS OF THE TRACKS OF PHOTO-ELECTRONS EJECTED FROM COPPER BY X-RAYS (WILSON)

It must have been while watching something of this kind that C. T. R. Wilson devised his scheme of making artificial clouds in the laboratory for his study of electronic motion. He put air saturated with moisture in a glass cylinder having a glass top and the lower end closed by a piston. When the piston was dropped the moisture condensed to form a cloud, if there were nuclei present. These nuclei might be dust particles, ionized or broken bits of molecules, or electrons.

Since one source of ionization is X-rays, a typical experiment is to pass a beam of X-rays through a chamber of this kind. In Figure 8 you see one of Wilson's photographs of the chambers containing electrons ejected by X-rays passing through a sheet of copper. These electrons, shot out of the air and the copper by the action of the X-rays, are the X-ray photo-electrons. The path of the photo-electron is made visible by condensation or drops of moisture on it. The cloud is not a fuzzy one such as we see in the sky, but is a fog; it occurs along more or less definite lines, these lines being the tracks of the electrons.

Perhaps the most interesting characteristic of photo-electrons is their high speed. Their speed can be measured in a number of ways. Let us suppose that cathode electrons (see Figure 9) strike the target T with a speed of one hundred miles per second. The resulting X-rays after passing

through the tube wall are allowed to strike a metal plate P from which they eject a photo-electron. These photo-electrons will have a variety of speeds, the fastest going with almost identically the speed of that of the original cathode electrons.

If we attempt to explain this speed in terms of waves we get into serious difficulties. Waves spread in all directions. If we think of them as spherical waves going out in a given direction, only a small portion of them will land on an electron in P. How could this small portion of the wave eject the photo-electron at such high speed?

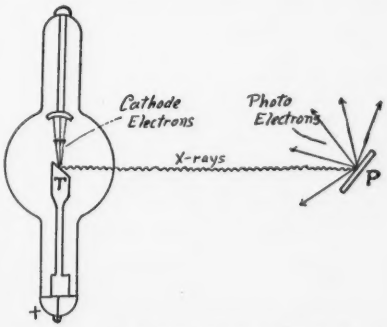

FIGURE 9.—THE SPEED OF THE PHOTO-ELECTRONS

The question reminds me of an experience in my early boyhood. A portion of our summer vacations were spent at Otsego Lake in Northern Michigan. Around a point about a quarter of a mile from the camp there was an excellent swimming place where the beach went out slowly and then down suddenly. My older brother built a diving board there; I had a diving board over the shallow water in front of the camp. One hot, calm July day, my brother dived from his board into the deep water, the ripples from the resulting splash spreading out over the lake. By the time the ripples had come around the point to where I was swimming, half a mile away, they were of course too small to be noticed. You can imagine my great surprise, therefore, when these small ripples, striking me as I was swimming near my pier, suddenly lifted me from the water, and set me on my diving board.

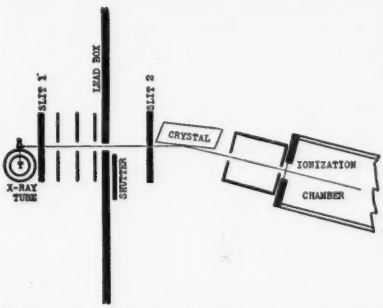

FIGURE 10.—THE WAVE-LENGTH OF THE X-RAYS

Of course such a story is incredible, but if it is impossible for a water ripple to do such a thing, it is just as impossible for an electron, diving into the ether at T, thereby setting up an ether ripple, to jerk an electron out of P as a photo-electron having the same energy as the one which dived into T. It was arguments of this kind which made Einstein think that the wave theory was insufficient to explain the

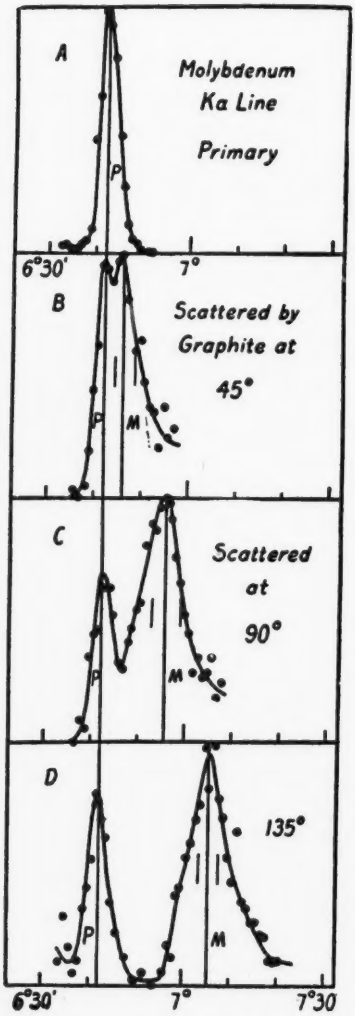

FIGURE 11.—SPECTRA OF SCATTERED X-RAYS (*below*) COMPARED WITH THE SPECTRUM OF THE ORIGINAL X-RAY (*above*)

photo-electric effect. Let us suppose that the cathode electron as it strikes the target T expends its energy in the production of one such photon (or X-ray). This photon will shoot over to P and expend its energy on an electron, which will come off with all of the energy of the initial electron. In this way it is possible for us to account in a satisfactory manner for the speed of the photo-electrons when produced by either X-rays or light.

It was Jeans who remarked, I believe, that the photo-electric effect was itself not complete evidence of the existence of photons, because the picture of photons had been devised to account for the photo-electric effect; and it would be a poor theory which did not account for the thing for which it was devised. He suggested that it would be much better to find some other way to explain this fact for which it was not particularly invented.

Such has since been found in connection with scattered X-rays which are very much like echoes. We see our hands by scattered light. If the light were replaced by an X-ray tube, our hands would throw scattered X-rays into our eyes. If these X-radiations were allowed to fall on a piece of paper, the rays scattered by the paper would be of a shorter wave-length than of the rays received by the paper. As the paper is turned, the edge eventually facing the observer, the color changes to that of the longer wave-lengths. According to the wave theory it is hard to account for this change in wave-lengths, because on the wave theory as many waves must leave the paper as strike it, and the scattered ray would have to be of the same frequency as the

primary ray. When one whistles in front of a wall with a frequency of, let us assume, five hundred vibrations per second, the wall vibrates with the same frequency and in turn throws the same frequency into our ears. In the case of scattered X-rays, the echo should similarly be thrown back by the electrons in the scattering material, and should likewise have the same pitch or frequency as the incident rays.

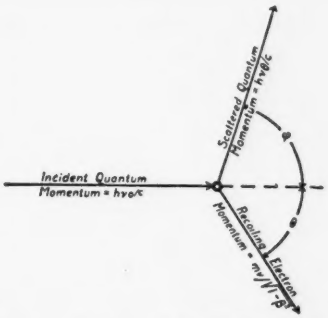

FIGURE 12.—RECOIL OF AN ELECTRON

A few years ago in St. Louis we measured the pitch of scattered X-rays, using the apparatus shown in Figure 10. Rays from the target T (see Figure 9) of the X-ray tube were scattered by a block of carbon at R, and the pitch (or wave-length) of the echoed rays measured by an X-ray spectrometer shown at the right of the lead box. By swinging the tube itself in line with the slits, it was possible to get a direct comparison with the wave-length of the original rays.

The results are shown in Figure 11. The upper curve (see Section A) gives the plotted spectrum of the original X-ray beam. In Sections B, C, and D are shown the spectra of the X-rays scattered by carbon in the three directions, 45°, 90°, and 135°, respectively. A part of the scattered rays are of the original wave-lengths; but most of them are increased in wave-length. This corresponds to the lower pitch of the echo when compared to the pitch of the original sound.

FIGURE 13.—RECOIL ELECTRONS

How could that come about? We find it very difficult to account for it on the basis of the wave theory, but the photon picture suggests an easy interpretation. In Figure 12 we picture the X-ray not as a group of waves, but as a particle (or photon) striking the electron. As this photon glances off in one direction, it causes the electron to recoil. It is like hitting a football with a golf ball. The golf ball may go off in one direction, and the football in another. Part of the energy of the golf ball will be expended in setting the football in motion; likewise a deflected photon has

less energy than the incident photon. This reduction in energy of the X-ray photon corresponds, according to Planck's original quantum theory, to a decrease in frequency (or increase in wave-length) of the scattered X-rays, just as the experiments show. In fact, the theory is so definite that it is possible to calculate just how great a change in frequency should occur.

If this explanation is the correct one, there should have been an electron recoil as a result of the process. At the time the theory was proposed, such electrons had not been observed, but almost immediately afterward C. T. R. Wilson, using his cloud expansion chamber, found them. One of his typical photographs is shown in Figure 13. The X-rays are going from left to right. Near the top and bottom are the trails left by two

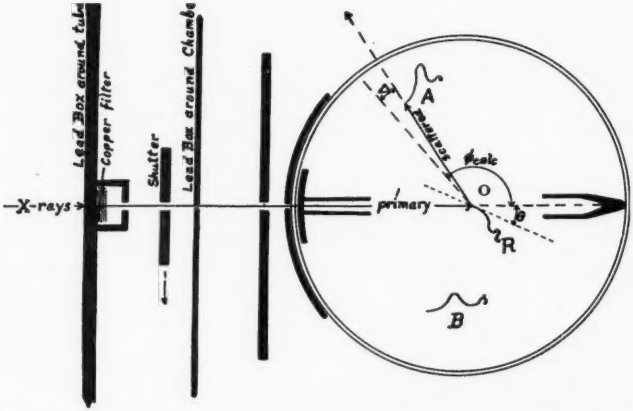

FIGURE 14.—DIAGRAM OF AN EXPERIMENT SHOWING THE DIRECTION OF THE DEFLECTED PHOTON AND ALSO OF THE RECOIL ELECTRON

photo-electrons which have taken up the whole energy of a photon. Between these are a number of shorter trails, all with their tails toward the X-ray tube. These are the electrons which have been struck by flying X-ray photons. Some have been hit squarely and knocked straight ahead; others have received only a glancing blow and recoiled at an angle. Here may be observed not only the loss in energy of the deflected photons, as shown by the lowering in pitch of the X-ray echo, but also the recoiling electrons from which the photons have bounced.

To make doubly certain, an experiment was tried to see whether the direction relations between the deflected photon and recoiling electron were right. A diagram of the apparatus used is shown in Figure 14. A beam of X-rays, so feeble that on the average only one or two recoil electrons appeared at a time, was shot into the expansion chamber. In the chamber every electron

thus set in motion was photographed. Let us suppose, as in Figure 14, that the electron struck by the photon recoils downward. This must mean that the photon has been deflected upward toward A. If this photon should strike another electron before it leaves the chamber, as sometimes happens, the collision would occur at some point along the line OA; it cannot occur on the same side as the recoil electron (beta ray). On the wave theory, if the photon is a wave, spreading in all directions, there would be just as much reason to expect a second beta ray at B, as at A. On performing a series of experiments, we found that the second electron, when observed at all, was found relatively in position A. This being a crucial test, it is evident that an X-ray is scattered in a definite direction like a corpuscle.

Light Consists of Both Waves and Particles

At the time we came to this conclusion, it was not known that other things which we knew had the characteristics of particles also had the characteristics of waves. It was somewhat of a comfort to us to soon find L. de Broglie of Paris asking himself a similar question relative to electrons. By an extension of Planck and Einstein's quantum theory de Broglie was able to compute what the wave-length corresponding to a moving electron should be. Davisson and Germer at New York, Thomson at Aberdeen, and others subjected de Broglie's theory to experimental test. They were able to show that with electrons one could get the same type of deflection that we had with X-rays and light.

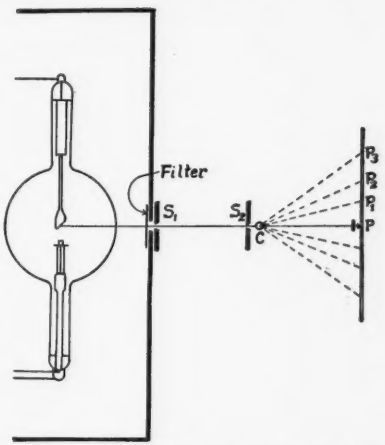

FIGURE 15.—HULL'S ARRANGEMENT FOR DIFFRACTING A BEAM OF X-RAYS BY A MASS OF POWDERED CRYSTALS

Our crucial evidence for the wave character of light was the fact that light could be diffracted by a ruled grating. X-rays were diffracted in the same way, but before this was known to be possible, they were diffracted by the regularly arranged atoms in a crystal—these atoms taking the place of the lines on the ruled mirror.

Figure 15 shows how the electron experiment has been done by Dr. Hull at Schenectady. X-rays were passed through a pair of diaphragms and a mass of powdered crystals placed at C, and struck a photographic plate at P. Rays diffracted by the layers of atoms in the crystals hit at such points as P_1, P_2, etc., giving rise to a series of rings about the center. By using

aluminum crystals at *C*, Hull obtained the photograph shown in the left section of Figure 16. It was this crystal diffraction that first gave convincing evidence that X-rays, like light, consist of waves.

G. P. Thomson performed a precisely similar experiment with electrons, by substituting cathode electrons and gold leaf, respectively, for the X-rays and aluminum crystals in Figure 15. The result is shown in Figure 16 (right). Although not quite as sharp as in the upper photograph, the central image and several rings of diffracted electrons are distinctly visible.

If the right photograph in Figure 16 shows that X-rays have the characteristics of waves, then the left one demonstrates that electrons also have the characteristics of waves. Yet these are the same electrons that

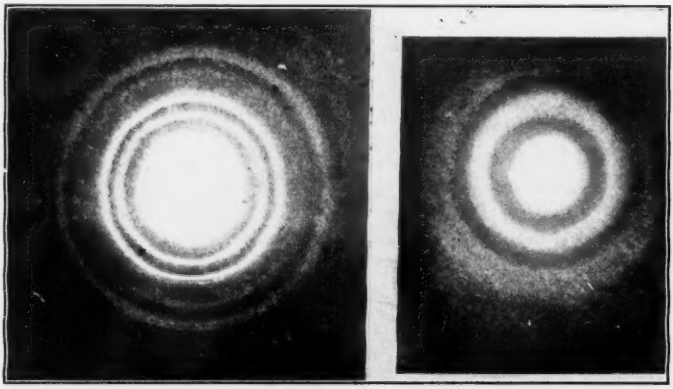

FIGURE 16.—DIFFRACTION PATTERNS

Left—beam of X-rays traversing a mass of aluminum crystals (Hull).
Right—beam of electrons traversing a mass of gold crystals (G. P. Thomson).

were shown in the photograph (Figure 8) in which the trails were so obvious. It was only last Christmas that Professor Arthur J. Dempster at Chicago obtained similar results with protons, getting a diffraction spot (see Figure 17) corresponding to each particular face in the single calcite crystal used at *C* in Figure 15. Thus we see that protons have wave characteristics, the same as do electrons and photons.

A Suggested Solution

During the last year or two there has gradually developed a solution of this puzzle, which though at first rather difficult to grasp, seems to be free from logical contradictions and essentially capable of describing the phenomena which our experiments reveal. A mere mention of some of

the names connected with this development will suggest something of the complexities through which the theory has gradually gone. There are Duane, Slater, and Swann in this country, de Broglie in France, Heisenberg and Schrödinger in Germany, Bohr in Denmark, and Dirac in England, among others, who have contributed to the growth of this explanation.

The point of departure of this theory is the mathematical proof that the dynamics of a particle may be expressed in terms of the propagation of a group of waves. That is, the particle may be replaced by a wave train—the two, so far as their motion is concerned, may be made mathematically equivalent. The motion of a particle such as an electron or a photon in a straight line is represented by a plane wave. The wave-length is determined by the momentum of the particle, and the length of the train by the precision with which the momentum is known. In the case of the photon, this wave may be taken as the ordinary electromagnetic wave. The wave corresponding to the moving electron has received no generally accepted name, other than the Greek letters Ψ $\bar{\Psi}$. Perhaps we may call it, however, by the name of its inventor, a de Broglie wave.

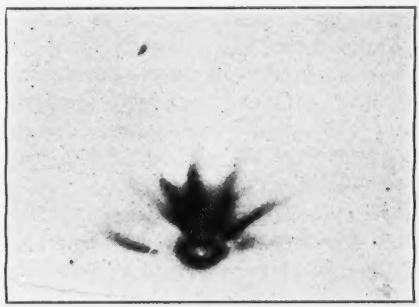

FIGURE 17.—DIFFRACTION PATTERN OF PROTONS REFLECTED FROM A CRYSTAL OF CALCITE (DEMPSTER)

Consider, for example, the deflection of a photon by an electron on this basis, that is, the scattering of an X-ray. The incident photon is represented by a train of plane electromagnetic waves. The recoiling electron is likewise represented by a train of plane de Broglie waves propagated in the direction of recoil. These electron waves form a kind of grating by which the incident electromagnetic waves are diffracted. The diffracted waves represent in turn the deflected photon. They are increased in wave-length by the diffraction because the grating is receding, resulting in a Doppler effect.

In this solution of the problem we note that before we could determine the direction in which the X-ray was to be deflected, it was necessary to know the direction of recoil of the electron. In this respect the solution is indeterminate; but its indeterminateness corresponds to an indeterminateness in the experiment itself. There is no way of performing the experiment so as to make the electron recoil in a definite direction as a result of an encounter with a photon. It is a beauty of the theory that it is determinate only where the experiment itself is determinate, and

leaves arbitrary those parameters which the experiment is incapable of defining.

It is not usually possible to describe the motion of either a beam of light or a beam of electrons without introducing both the concepts of particles and waves. There are certain localized regions in which at a certain moment energy exists, and this may be taken as a definition of what we mean by a particle. But in predicting where these localized positions are to be at a later instant, a consideration of the propagation of the corresponding waves is usually our most satisfactory mode of attack.

Attention should be called to the fact that the electromagnetic waves and the de Broglie waves are according to this theory waves of probability. Consider as an example the diffraction pattern of a beam of light, or of electrons, reflected from a ruled grating and falling on a photographic plate. In the intense portion of the diffraction pattern there is a high probability that a grain of the photographic plate will be affected. In corpuscular language, there is a high probability that a photon or electron, as the case may be, will strike this portion of the plate. Where the diffraction pattern is of zero intensity, the probability of a particle striking is zero, and the plate is unaffected. Thus there is a high probability that a photon will be present where the "intensity" of an electromagnetic wave is great, and a lesser probability where this "intensity" is smaller.

It is a corollary that the energy of the radiation lies in the photons and not in the waves. For we mean by energy the ability to do work, and we find that when radiation does anything it acts in particles.

In this connection it may be noted that this wave-mechanics theory does not enable us to locate a photon or an electron definitely except at the instant at which it does something. When it activates a grain on a photographic plate, or icnizes an atom which may be observed in a cloud expansion chamber, we can say that the particle was at that point at the instant of the event. But in between such events the particle cannot be definitely located. Some positions are more probable than others, in proportion as the corresponding wave is more intense in these positions. But there is no definite position that can be assigned to the particle in between its actions on other particles. Thus it becomes meaningless to attempt to assign any definite path to a particle. It is like assigning a definite path to a ray of light—the more sharply we try to define it by narrow slits, the more widely the ray is spread by diffraction.

It is only to satisfy our sense of continuity that we assume that an electron or a photon has a real existence between the occasions at which it acts on other particles. It would be equally permissible to suppose that light or cathode rays alternate in form between particles and waves. While moving from one place to another they would spread out as waves,

but when producing any physical effect they would materialize into discrete particles.

Perhaps enough has been said to show that by grasping both horns we have found it possible to overcome the dilemma. Though no simple picture has been invented affording a mechanical model of a light ray, by combining the notions of waves and particles a logically consistent theory has been devised which seems essentially capable of accounting for the properties of light as we know them.

Radio rays, heat rays, visible and ultra-violet light, X-rays, gamma rays, and cosmic rays all are thus different varieties of light. We find from our experiments on diffraction and interference that light consists of waves. The photoelectric effect and the scattering of X-rays give equally convincing reasons for believing that light consists of particles. For centuries it has been supposed that the two conceptions are contradictory. Goaded on, however, by obstinate experiments we seem to have found a way out. We continue to think of light propagated as electromagnetic waves; but whenever the light does something, it does it as photons. In reply to our question, what is light, the answer seems to come, waves and particles, light is both.

Power from the Sea. Persistent, resourceful, and wealthy is Georges Claude, French chemist of neon fame. Years passed after he developed his famous neon tubes before he convinced doubting Thomases of their commercial value. Now they are unescapable, their serpentine coils lividly lighting cities all over the world.

One purpose accomplished, Claude has been occupied for several years with the beguiling possibility of utilizing the thermic energy from the sea. Toward this end he is aggressively applying his Gallic persistence and his neon wealth.

Briefly stated, his idea is that a difference in temperature of 20 degrees centigrade is sufficient to produce steam, to condense it, and, during this process, to propel turbines. Using drinking water from a tap and a little ice, he once operated a turbo-generator before the "Académie des Sciences." The condensing effect of ice on the turbine exhaust was sufficient to give him a usable heat cycle.

Indifference to this demonstration impelled him to something more spectacular. He went to Ougree, Belgium, on the Meuse, and built there an experimental turbine of 60-kilowatt capacity. Utilizing an 18-degree difference of temperature between surface water and water deep down he ran his turbine, according to his report, at 6000 r. p. m.

That trite, but incisive flaunt, "impractical," was still hurled at him. Consequently he boarded his yacht and sailed to Cuba, there to discover near Matanzas a difference in temperature of 20 and sometimes 30 degrees centigrade between surface water and water at a depth of 1500 feet. He installed his plant only to have it accidentally disabled for a year.

Reports now come that he is persisting in his efforts to employ this temperature fall—"as good as a water fall." Will it prove to be another neon success? Skeptics abound, but they are only bait for Dr. Claude. He calmly insists that solar heat is the only worthwhile source of power.—*Tech. Rev.*, **32**, 359 (May, 1930)

GYPSUM AND GYPSUM PRODUCTS

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Introduction

The use of gypsum as a building material dates back to the dawn of recorded history. The ancient Pharaohs of Egypt used it in the construction of their royal tombs almost 5000 years ago. The use of calcined gypsum, the plaster of Paris of today, is recorded in the masks and models found in the ruins of cities of Amenophis the IV, while in ancient Greece, friezes, mountings, and casts are found in which it is the main structural material. Grecian temples of the pre-Christian era made abundant use of gypsum plaster; from this period its use is recorded continuously in the ancient monasteries and cathedrals of France and Germany up to structures of modern times. However, not until comparatively recent times have rapid strides been made in the development and use of gypsum products. The use of such products in engineering and building construction lines has been steadily increasing, and this increase will continue, most likely, because of the dwindling supply of wood as a building material. The money value of gypsum and its products amounts to over fifty million dollars for an annual production of five and one-half to six million tons. An industry like this, comparatively young and apparently at the threshold of a diverse and rapid expansion, merits the attention of every student of national resources.

Definition of Gypsum

The name *gypsum* is given to the hydrated, crystalline forms of calcium sulfate as they are found in nature. The composition of pure gypsum may be represented adequately by the formula $CaSO_4 \cdot 2H_2O$. Thus, in per cents, the pure gypsum may be said to be made up of 32.6% calcium oxide, 46.5% of sulfur trioxide, and 20.9% of water. As mined, however, the gypsum contains and is mixed with a number of impurities, such as silica and other earthy materials. These include clay, calcium and magnesium carbonates, iron oxide, and alumina.

The chemical change that makes gypsum important as a building material is a partial dehydration, according to the reaction

$$CaSO_4 \cdot 2H_2O \rightleftharpoons CaSO_4 \cdot {}^1/_2H_2O + 1{}^1/_2H_2O.$$

This partial dehydration, to be described in detail in a later section, is carried out at temperature elevations up to about 205°C. The $CaSO_4 \cdot {}^1/_2H_2O$, known as hemi-hydrate and as plaster of Paris, possesses the property of adding on $1{}^1/_2$ molecules of water to re-form gypsum crystals, a property essential to its use as a plaster material.

Forms of Gypsum Mineral

Physically, gypsum exists in several crystalline modifications or forms. A nearly transparent crystalline form is known as *selenite;* a clean fine-grained massive form is known as *alabaster;* and the most common ordinary non-transparent, massive form is designated as *rock* or *massive gypsum.*

Selenite or *transparent gypsum* occurs as large, colorless, transparent crystals; they may be massive or they may possess a distinct foliated structure, reminding one somewhat of the laminated structure of mica. Selenite may be separated, accordingly, into a series of thin plates possessing a slight flexibility but no elasticity. This fact distinguishes selenite from mica, with which it is often confused. When selenite occurs in massive form, it may readily be distinguished from calcite by its hardness; the selenite crystal is easily scratched by the finger nail, while calcite is too hard to be thus scratched. The selenite crystals follow the monoclinic system; the cleavage is in three directions and is perfect along the principal plane.

Alabaster or *snowy gypsum* is a form of massive gypsum which is especially free from impurities and is pure white in color. The crystals of the monoclinic system are exceedingly small, producing a smooth, fine-grained mass. A cut or carved surface may be given a high polish, presenting a smooth, velvety finish of even texture. This property, together with its pure white color, has long made alabaster a favorite statuary material, famous in song and legend.

The other forms of *massive* gypsum differ from one another chiefly in the amount and nature of the impurities they contain and in the state of subdivision in which they are found. Thus there are recognized *gypsum earth* or *gypsite* and *gypsum sand.*

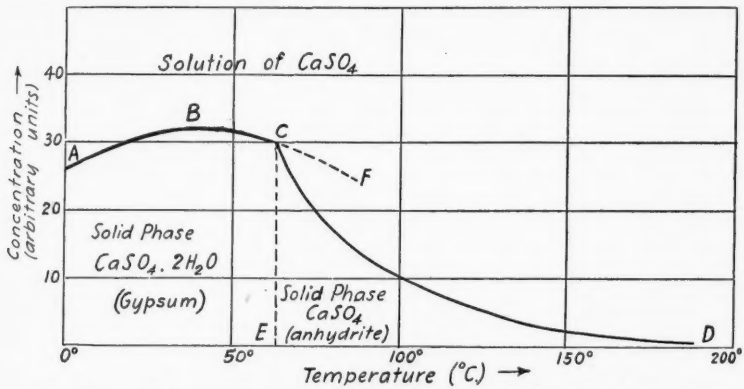
Satin spar is a less frequent form of gypsum, in which the crystals take the form of long slender needles and have a pearly luster. The general appearance and shape of these crystals give the mass a decidedly fibrous and satin-like appearance, responsible for its name.

Gypsum rock is not a hard mineral, as already indicated; on Mohr's scale of hardness it is usually placed at 1.5 to 2.5, depending upon the particular variety. It has a specific gravity of 2.3–2.4 grams/cc.

Relation of Gypsum to Anhydrite

The anhydrous sulfate of calcium found in nature or produced from gypsum is known as *anhydrite.* Its composition is expressed by the formula $CaSO_4$. To account for the occurrence of both gypsum and anhydrite in nature, it is desirable to discuss briefly the relation of gypsum to anhydrite.

Gypsum and anhydrite crystallize in different crystal systems, which gives them properties different from each other. Anhydrite, $CaSO_4$, resembles fairly closely in physical properties the sulfates of strontium, barium, and lead; gypsum, however, differs markedly from these sulfates. The solubility of gypsum is often said to decrease with a rise in temperature; this statement, however, must be carefully examined to appreciate the truth it contains. The solubility of gypsum actually *increases* very slightly up to about 40°C. and then begins to decrease at about the same rate. The solid phase, in contact with the saturated solution, is solely $CaSO_4 \cdot 2H_2O$. But at 60–65°C. the solubility decreases quite rapidly and the solid phase becomes anhydrite, $CaSO_4$. Thus, it becomes evident that from a saturated solution of calcium sulfate above 60–65°C., an-



TEMPERATURE-CONCENTRATION DIAGRAM SHOWING THE RELATION BETWEEN GYPSUM AND ANHYDRITE

Diagram after RASTALL, "Physico-Chemical Geology," Edward Arnold and Co., London, 1927, p. 181.

hydrite crystals may be crystallized out, while below this temperature region, crystals of gypsum make their appearance. This temperature region is often known as the inversion point or region.

The presence of other salts influences markedly the position of this inversion point. Thus if the solution of calcium sulfate be also saturated with common salt, the inversion point is lowered to about 30°C. Above 30°C., under these conditions, the solid phase separating out is anhydrite.

Origin of Gypsum and Anhydrite Deposits

All gypsum deposits are of a sedimentary nature and most of the deposits which are of commercial value were precipitated from water solution. All natural waters carry some mineral constituents in solution

and if these dilute solutions are concentrated by evaporation the salts will be precipitated out. The order of precipitation and deposition are controlled by the solubility of the salt and the relative proportion in which its ions are present. Most natural waters carry in solution calcium, sodium, bicarbonate, chloride, and sulfate ions as the chief soluble constituents. If such a water is evaporated and the solution of these ions be thereby concentrated, there will result deposits of limestone, calcium sulfate, or rock salt.

However, if the solution be that of ordinary sea water, the *first* salt to separate out on concentration is a form of calcium sulfate. If the concentration of the sea water is taking place slowly at low temperatures (30°C. or below) by ordinary solar evaporation, the calcium sulfate formed is the di-hydrate or *gypsum*. The rate of evaporation and the cyclical nature of the depositions will account for the foliated selenite or a bulky or a fine-grained massive gypsum. Thus those regions which were formerly covered by the sea are the regions in which gypsum deposits are most likely to be found.

Likewise, if the temperature of the sea water is 30°C. or above during the concentration process and period, the calcium sulfate depositing is the *anhydrite* form. Such temperatures are not at all improbable during the summer months or in tropical climates.

Deposits of gypsum or of anhydrite which have been deposited in this manner will naturally be found in the form of strata or beds. Gypsum is generally found in the form of beds which are interstratified with thin beds of limestone, thicker beds of shale or clay, and at times small amounts of rock salt. These beds may vary in thickness from a few inches to several hundred feet; the workable deposits, however, are hardly ever less than six feet in thickness.

If the water from which the gypsum is being deposited is clear and free from sediment, the gypsum will be pure. But should the water carry suspended matter, the gypsum crystals will be intermingled with these impurities.

In the arid regions of the Southwest, notably in Arizona and New Mexico, extensive deposits of gypsum sands occur. These sands are composed of fine grains of gypsum mixed with sand. The fine grains of gypsum are the resultant of the eroding action of wind and sand upon some outcrop of massive gypsum; these sands always occur in the vicinity of some massive gypsum deposit, confirming the theory of their formation.

Gypsum earth or *gypsite* consists of small angular crystals of gypsum with rounded points intermingled with small crystals of quartz, considerable quantities of poorly crystallized calcite, and some organic matter. The rounded edges or points of the gypsum crystals suggest a recent dissolving action of ground waters upon crystals already formed. The inter-

mingling of impurities with these crystals of gypsum is accounted for most readily by the theory that waters saturated with the gypsum constituents and other salts were repeatedly evaporated in low areas, thereby causing a deposition of gypsum crystals. The subsequent movement of earthy material by wind and water caused intermingling of this material with the gypsum crystals. The rounding off of the crystals edges, too, is the resultant of the partial solution of these crystals by fresh storm waters. As in the case of gypsum sands, the gypsite deposits occur in those localities in which massive gypsum deposits are located; the secondary nature of their formation is, hence, amply verified.

Geological Age and Geographic Distribution of Gypsum Deposits

Gypsum may be deposited and, as a matter of fact, is found in almost every geological age. The *workable* deposits, however, of North America are confined to relatively few geological horizons. The Salina group of *Silurian* contains large deposits of massive rock gypsum, which is being worked in New York, Ontario, Ohio, and in a part of Michigan. The *Lower Carboniferous* contains large deposits which are being worked in New Brunswick, Nova Scotia, Virginia, Montana, and in Michigan.

The gypsum deposits which occur west of the Mississippi generally belong to the *Permian* or somewhat later ages. Among these may be mentioned those occurring in the Black Hills of South Dakota, in the vicinity of Fort Dodge, Iowa, in several localities in Kansas, throughout the western part of Oklahoma, in a narrow strip just east of the escarpment bordering on the Llano Estacado in Texas, and in the southeastern portion of New Mexico. With the exception of the deposit in Montana, which is known to belong to the *Carboniferous*, and the deposit in California, which is known to belong to the *Tertiary*, the geologic relation of the gypsum in the other Western states is not definitely known. These states include Wyoming, Colorado, Arizona, Utah, Nevada, and Oregon. The deposits of these states have been variously assigned to the *Carboniferous*, *Devonian*, *Permian*, *Jurassic*, *Triassic*, etc.

The Canadian deposits of Newfoundland, New Brunswick, and Nova Scotia belong to the *Lower Carboniferous*. The deposits of southern Ontario belong to the Salina group of the *Silurian*, while those occurring in the vicinity of the Moose and French Rivers near James Bay are of *Devonian* age. As in the United States, the gypsum deposits of the Western provinces generally belong to the younger formations. Workable deposits are located in the Lake Manitoba region, in Alberta, and in British Columbia. Other workable deposits are located in regions at present too far removed from market.

The ranking of the states in gypsum production is given by the following arrangement in decreasing order of production: New York, Iowa,

Underwood and Underwood

THE HEART OF THE VALUABLE 270-MILE GREAT WHITE GYPSUM DEPOSIT NEAR ALAMOGORDO, NEW MEXICO

Michigan, Texas, Ohio, Oklahoma, Nevada, Utah, Arizona, California, Colorado, New Mexico, Oregon, South Dakota, Virginia, and Wyoming. The total production of these states combined is very close to six million tons per year.

Properties and Uses of Gypsum

When gypsum is heated to temperatures above 100°C. it dissociates partly, giving up part of its water of crystallization. This dissociation proceeds more readily as the temperature rises, but if it is heated above about 205°C. there is a probability that the dehydration will be complete. The extent of dehydration that is desirable is three-fourths of the water of crystallization, expressed by the equation

$$CaSO_4 \cdot 2H_2O \rightleftharpoons CaSO_4 \cdot {}^1/_2H_2O + 1{}^1/_2H_2O.$$

The hemi-hydrate, known as plaster of Paris, is in a condition of unstable equilibrium with respect to moisture. If it be placed in contact with water, it will unite with enough water to revert to the original crystalline dihydrate, gypsum. The crystal formation, taking place rather rapidly, will produce a mass of interlacing crystals. The resulting aggregate is a hard, compact mass, which is almost as hard and which has all the properties of the original gypsum rock from which it was produced. This *setting* into the finished hard form is desirable, of course, in every building use of this plaster.

A certain time interval elapses before the hemi-hydrate hydrates to gypsum after it is mixed with water—before it takes its initial set. The length of this time interval depends upon the purity of the crude gypsum from which the hemi-hydrate was made and upon the method of its manufacture. Pure hemi-hydrate takes the initial set within a very short time after it has been mixed with water. But if the crude gypsum contained clay, limestone, sand, and other similar impurities, or if a material, such as glue or other organic matter, has been added during the process of manufacture the time interval before the initial set takes place will be greatly increased. This increase in setting time will be proportional, roughly, to the nature and the amount of impurity, *retarder*, that is present.

If the gypsum has been heated, during the process of *calcination* or dehydration, for some time to temperatures above 205°C., more than three-quarters of the water of crystallization may have been driven off. The product thus may have been converted completely into $CaSO_4$, without any water of crystallization, or part of the mass may have been thus converted. If the dehydration has been complete the mass is known as *dead-burned* gypsum and not as plaster of Paris. The time of setting of this dead-burned gypsum is very much longer than that of the hemi-hydrate; certain specific demands require this dead-burned gypsum and it is being

Certain-teed Products Co., New York City

GYPSUM MINE, FORT DODGE, IOWA

manufactured on a small scale. However, the building trade demands a relatively quick-setting product, resulting in the production, principally, of the hemi-hydrate.

If the hemi-hydrate—or plaster—is mixed thoroughly with water, it develops a condition of high plasticity before it assumes its set. In this plastic state it can be troweled, cast, or molded into any desired form. On setting, the plaster retains the form into which it has been molded and hardens into a firm, rock-like mass without cracking or otherwise marring the surface. There is, in fact, an expansion during the setting process, which tends to fill out every nook and cranny of the mold, producing sharp, clear outlines and details. Gypsum plaster is highly fire-resistant and an excellent heat insulator. These properties make its use permissible in the construction of fireproof buildings and in those special conditions where heat losses, in either direction, are to be avoided.

The *uses* of gypsum may be divided into *three* classes, depending upon the particular property of the material which is of importance.

1. There are those uses which depend upon the properties of the calcined product, described above, such as wall plaster, statuary, ornamental work, etc.

2. There are those uses which depend upon the chemical properties of the gypsum itself, such as a retarder for portland cement and in fertilizers.

3. There are those uses which depend upon the physical properties of gypsum mineral, such as in the manufacture of paints, sizing of paper, etc.

The building trade consumes about 95 per cent of the calcined product—plaster, while special ornamental and scientific uses demand only five per cent. The total calcined product amounted to about four million tons last year in the United States. By far the largest fraction of this was used in the manufacture of fibered plaster, a plaster reinforced by vegetable or animal fibers or hairs. Next in order of importance and quantity consumed come neat plaster, wall board, sanded plaster, plaster board and lath, partition tile, plaster of Paris, Keene's cement, roofing tile and blocks, and insulating materials, either in block or ground form. The actual production of these materials will be described briefly in a later section.

About one-fourth of the total gypsum products sold in the United States last year was in the form of crude or uncalcined gypsum, amounting to a little over one million tons. Of this quantity, 95 per cent was consumed by the portland cement industry as a retarder in cement setting, $2^1/_2$ per cent was used for agricultural purposes as a constituent of fertilizers and a soil corrective; and the remaining $2^1/_2$ per cent was used by the paint and paper industries and in certain minor industries.

The value of gypsum or of plaster of Paris in portland cement is due to its action as a retarder. The retarding effect, up to three per cent of gypsum, is directly proportional to the sulfate content. Above three per cent the retardation diminishes and gradually becomes negative. Too large quantities of gypsum in cement, too, lower the tensile strength of the concrete. Accordingly, most portland cements, of the high-lime variety, use the minimum amount of gypsum that will produce the desired setting properties. The average for this type of cement is about two per cent of gypsum. Most manufacturers add the gypsum to the charge after the cement clinker has been formed and before grinding. During the grinding process a considerable amount of heat is generated which calcines, in part at least, the gypsum to the hemi-hydrate. Some manufacturers add calcined gypsum to the clinker before grinding instead of the gypsum; these are, however, in the minority.

The use of gypsum as an indirect fertilizer and as a soil corrective is of long standing. As a matter of record, the first gypsum deposits developed in the United States were for the purpose of supplying gypsum as a fertilizer. The use of gypsum for this purpose has steadily declined, however, since the advent of potash salts. Many theories have been advanced to justify the use of gypsum in soils for agricultural purposes. The most probable explanation outlines a three-fold value of gypsum in soil. *First,*

U. S. Gypsum Co., Chicago

LOADING GYPSUM ROCK AFTER BLASTING

gypsum seems to act like lime in flocculating loose soils and to disintegrate or loosen up tough clay soils; *second*, gypsum may serve to hasten catalytically the oxidation of certain organic or nitrogenous constituents of the soil; and *third*, gypsum will gradually decompose, by reaction, the double silicates containing potash, liberating the valuable plant food, potassium sulfate. Accordingly, soils deficient in potash may be benefited by the addition of gypsum, while soils containing sufficient potash in available form do not seem to benefit by its addition.

The snowy whiteness of pure gypsum has brought about its use in certain classes of paints. This use is not always a legitimate one, for, generally speaking, it is added as a cheapener of paints. It not only cheapens the cost but it cheapens the wearing qualities of the paint. The solubility of gypsum, limited though it be, is a pertinent objection to its conclusion in outside paints, and its lack of hiding power makes its use in any paint a questionable procedure. Some tinting pigments are oftentimes changed (quite legitimately) in shade and effect by the addition, during the process of their production, of finely ground gypsum.

The addition of finely divided gypsum to the paper felt in the process of making paper is for the purpose of giving body to the finished sheet, and with the coöperation of the size, a smooth surface which takes printer's

ink more readily to give a clearer impression. Fairly large quantities are thus used in the paper industry.

Mining of Gypsum

The mining of rock gypsum follows the same procedure as that of most earthy materials. If the deposit occurs near or at the surface, open pit mining is usual. The pit is opened in a manner to expose the gypsum in a vertical face. The "over burden," the foreign material covering the deposit, is removed ("stripped off"), leaving a clean block of rock gypsum exposed. The blasting operations, with blasting powder, remove the gypsum in large blocks, just as in stone quarrying. The blast usually throws the gypsum into the floor of the pit, from which it is removed by power shovel or by hand into cars carrying it to the plant.

If the over-burden is too large in amount or of such a nature as to make the cost of stripping excessive, underground methods must be employed. Frequently, operations are begun in an open pit on the outcrop of the gypsum bed and are carried on until the over-burden removal becomes excessive. Tunnels are then driven into the deposit and the mining operations are underground. A typical underground mining method is described by Crane* as follows:

> As a rule there is little or no system employed in laying out the workings. Main lines of haulage are run as continuation of the surface drifts, other openings being run parallel with them on further development or run from the foot of a shaft sunk to the workable deposit. On one or both sides of the haulage ways, rooms are driven, which often run together, thus leaving odd and very irregular pillars. Long working-faces are often formed, which must be again broken by passages forming pillars for the support of the roof. Usually, however, single rooms, more or less irregular in shape, are opened up and worked until the handling of the product becomes inconvenient, when new and more advantageously placed openings are begun.

The mining of gypsite or gypsum earth is made relatively simple by the fact that such deposits occur near the surface and are of a soft, granular nature. The small over-burden of sand or soil is removed, the gypsite is loosened by means of plows or disk harrows, and the loosened material collected by means of drag scoops, Fresnos, or wheeled scrapers. Mine cars transport this material to the mill.

Grinding and Crushing Operations

The processes by which gypsum are prepared for the market are very similar, though the products have widely different uses and characteristics. These operations are (*a*) grinding and (*b*) calcining. The order of these operations depends upon the method of calcining employed.

* CRANE, W. R., *Engineering and Mining Journal*, **17**, 442 (Mar., 1904).

U. S. Gypsum Co., Chicago

MIXING RED TOP PLASTER ON THE JOB

If the *kettle process* is employed, the most-used American process, the grinding is done before the calcination; if the *oven process* is used, the calcination comes before the grinding. In a modified rotary oven process, the gypsum rock is crushed before calcination and then finally ground. The crushing and grinding operations, hence, will be discussed first.

The lumps of rock gypsum, as received from the mine, are first crushed to lumps about two inches in diameter by means of jaw crushers of the Blake type. From these crushers or "nippers," the material is fed into "crackers," grinders of the usual coffee mill type, in which the gypsum is reduced in size to $^1/_4$" or less. From these, the material passes into "disintegrators," such as the Sturdevant rock emery mill or the Raymond Impact pulverizers, where the particle size is reduced until about fifty-five to sixty per cent will pass a 100-mesh sieve. The material is now ready to be calcined, following the usual American practice.

The Calcining of Gypsum

The ground gypsum is passed into *kettles* or the coarsely crushed gypsum into *ovens* of the stationary or rotary type for calcination. The following paragraphs will describe these processes.

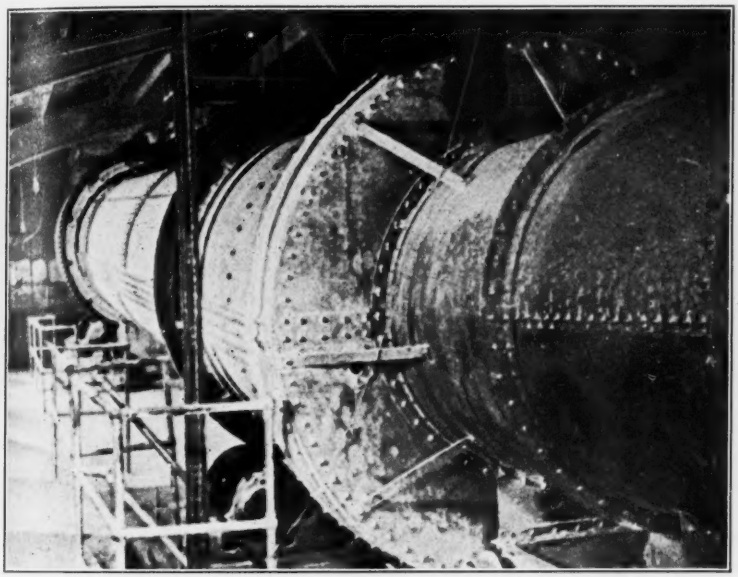
In the *kettle* process, use is made of a cylindrical steel tank which has a

U. S. Gypsum Co., Chicago

LOADING RED TOP PLASTER INTO THE CAR

concave bottom of cast iron or pressed steel. Standard sizes of these kettles are eight and ten feet in diameter and six to eight feet in depth. The kettle is set into a heavy masonry support and includes an ample combustion space directly underneath the concave kettle bottom. The kettle and its contents are heated on the bottom by direct radiation and direct contact with the hot flue gases; in addition most kettles have built into them either two or four flues through which the furnace gases are led on their way to the stack. In order to prevent local overheating and to promote uniform mixing, the kettle is provided with a stirring mechanism that moves the mass from the bottom and the outer edges toward the center, allowing cooler gypsum to work its way toward the hotter sides and bottom. The charge varies from eight to fifteen tons of ground gypsum. This charge is fed in slowly through a port in the lid, the total time of loading ranging from thirty minutes to one hour. During the loading period the stirrer is operating continuously and the temperature is being raised gradually until, at complete loading, the temperature has reached 170–175°C., the optimum calcining temperature for pure gypsum, or 200–205°C., the optimum temperature for gypsite.

At 110°C. the evolution of steam becomes quite rapid, lifting and throwing the powdered gypsum about and making it appear as if the mass were



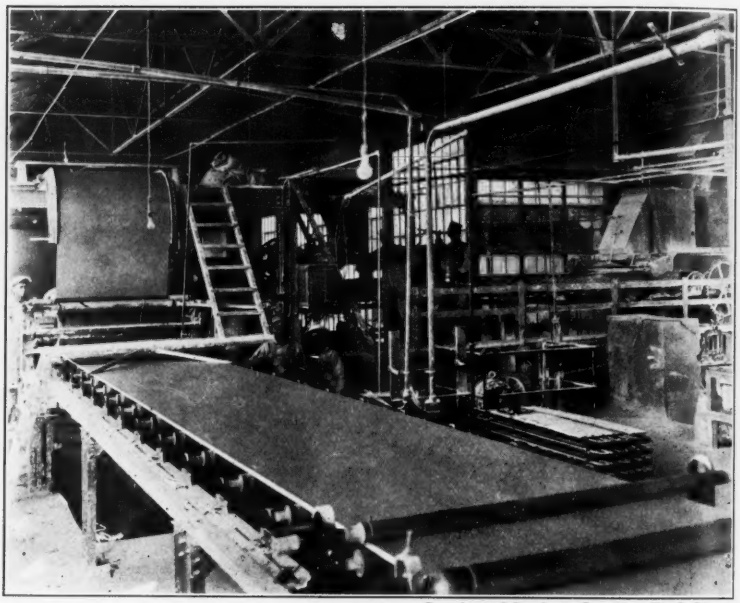
U. S. Gypsum Co., Chicago

ROTARY DRIERS

"boiling." This stage marks the loss of mechanically held water; as soon as this is driven off, the "boiling" ceases until a second "boiling" stage is reached at about 145°C. At this point the water of crystallization begins to leave until at the end, at temperatures ranging for the different raw materials from 170–205°C., three-quarters of the water of crystallization has been driven off. In practice, these temperatures are usually not measured by means of thermometers; rather the judgment of the calciner is relied upon to indicate the completion of the process and to insure a uniformity of product, especially when impure gypsum is the raw material.

When the calcination is complete, the fire is checked, and the calcined product allowed to flow (like water) into fireproof bins, where it is allowed to cool off for a short period. It is then elevated to screeners to remove foreign materials and lumps. The screened plaster is conveyed to storage bins for future packaging or manufacturing operations.

The kettle method is the oldest in point of service and is the most favored American process. Its disadvantages are due to its low and "batch" production, low heat efficiency, and its high power consumption for stirring. Accordingly, the kettle process has been discarded in some plants and a rotatory process installed instead with apparent marked success.



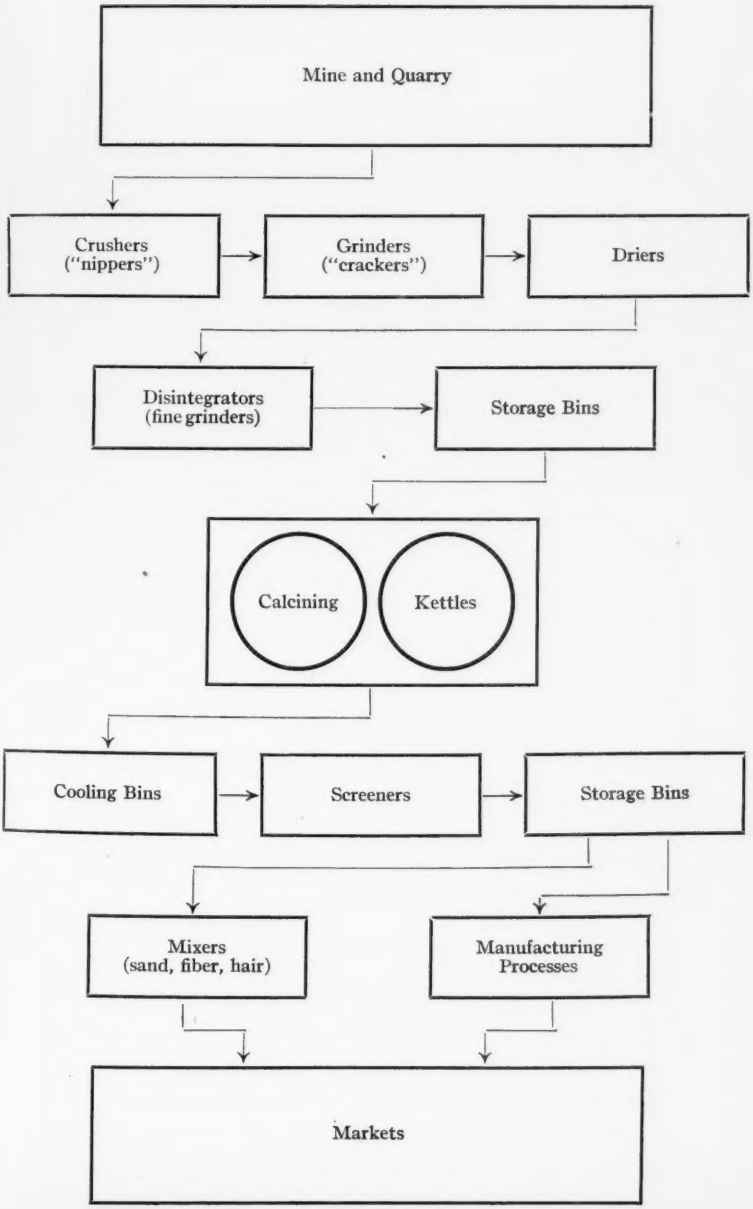
Certain-teed Products Co., New York City

GYPSUM BOARD MILL, ACME, TEXAS

This process promises to displace the older kettle in time as equipment is worn out and prejudice overcome.

The *rotary* process which is most used in the United States is the Cummer process. In this scheme the calciner consists essentially of a rotating cylinder completely enclosed in a brick setting and forming a "Dutch oven" extension at one end of the setting. The rotating cylinder is inclined at a small angle, allowing the furnace gases to pass up around it. Part of the hot gases enter the calciner through small openings through its shell at regularly spaced intervals; the major portion of the gases pass along the shell to its lower end and enter the calciner proper at this point. A number of chambers are built into the lower part of the setting with openings to the outside for the admission and control of secondary air, which in turn controls the temperature of the hot gases. These gases leave the calciner at its upper end after passing through its entire length, pass through a series of dust catchers, and finally pass up through the stack. The rotation of the calciner causes the gradual downward movement of the gypsum counter to the movement of the hot furnace gases. The temperatures of the gypsum during the process range approximately from 170–200°C., depending upon the density and purity of the rock gypsum.

A Typical Flow-Sheet of the Plaster Industry



No attempt is made to complete the calcining of the gypsum in the rotating oven; as a matter of fact, it is preferable to dehydrate it only partially to avoid local over-heating with its consequent *complete* dehydration. From the calciner the mass passes into fireproof bins, where it is held for a period of thirty-six hours. During the first part of this period, the heat of the mass completes the calcination process. Cool air is then allowed to circulate through the bins to remove the moisture and to cool the plaster lump. This lump is subjected to a grinding process preparatory for marketing or for processes of manufacture.

By a proper arrangement of bins for storage the process is made continuous. This continuity of process with the greater efficiency of heat transfer makes this process the most promising in American practice.

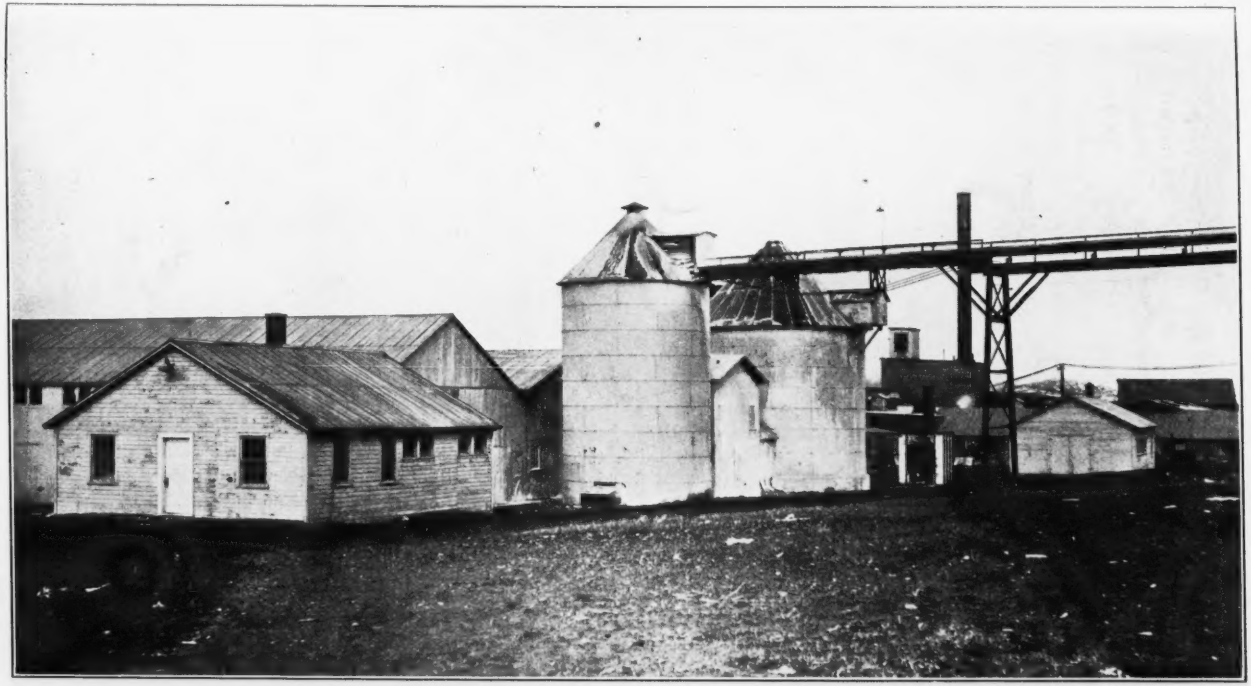
The Mannheim system, in use in Germany, is also a continuous process similar in the main to the Cummer process. The main differences lie in the more direct application of heat, the more thorough contact of furnace gases with the gypsum rock, and the quick removal of the finer particles to prevent over-calcination. The calcination, too, is completed in the furnace itself, and the process does not involve long storage for completion of the calcination process.

The *oven* process for producing plaster of Paris is still used in Europe for the manufacture of high-grade plasters. Relatively large lumps of rock gypsum are placed in an oven type furnace, the temperature of which is carefully controlled for long periods of time. After completion of calcination, the lumps are removed for grinding. This process is very costly both in labor and fuel; it has never found serious application in the U. S. (See page 2803 for a typical flow-sheet of the plaster industry.)

Special Gypsum Products

The comparatively recent introduction of manufactured forms of gypsum products, such as wall board, insulating blocks, plaster lath, etc., as well as the many specialized plasters of various compositions marks an interesting phase of the gypsum industry. These manufactured products have widened the scope of usefulness of the industry's products and have heightened the interest in gypsum as a national resource. A few typical manufactured articles will be discussed in the paragraphs that are to follow.

Gypsum Wall Board.—Under this name and under a variety of trade-marked names there are on the market sheets of gypsum which have been thus produced from the calcined gypsum. These sheets are used for interior home construction, where their heat-insulation and fire-resistant properties have made them welcome materials of construction. The thickness of sheet is generally either $^1/_4$ or $^3/_8$ inch, the width usually four feet, and the length six to twelve feet. The sheets are covered, usually on both sides, with a fairly thick, several-ply paper, which serves as a strength-



Certain-teed Products Corp., New York City

WALLBOARD PLANT, AKRON, NEW YORK

ener of the sheet and as an aid to decoration. The usual sawing, cutting, and nailing operations can be performed with this sheet as readily as with any other type of wall board. These gypsum sheets are made with and without sawdust, but the sawdust-containing product is preferable in most cases on account of its lightness.

The process of plaster board manufacture is an interesting one. If a sawdust plaster board is to be made, the finely screened sawdust and gypsum are fed, in proper proportions, from separate reservoirs into a mixing chamber. Wide (four-foot) "cupped" conveyor belts carry the mixture through water reservoirs, where the mixture absorbs enough water to form a slurry. Agitators of the revolving stirrer type thoroughly mix the mass, an accelerator is added, and the mass is dumped from the belts onto the forming machine. The slurry falls on a sheet of paper passing over a smooth iron table running at right angles to the conveyor belts; an upper sheet of paper is brought down upon the slurry and the whole is passed into a sheet of uniform thickness. As the sheet moves along another heavy roller smooths out any unevenness, filling depressions by pressure. As the board moves along slowly the calcined gypsum "sets" and hardens; as it finally crosses a small cutting table, it is cut to the desired length of six or twelve feet. The board now passes through driers through which hot air of about 105°C. is being circulated; after approximately an hour's drying, the boards are allowed to cool before inspection and shipment.

Since the finished board is a smooth, solid sheet of gypsum covered on both sides by strong, long-fibered paper, it may be used for ceilings, partitions, walls, etc. It does not warp or buckle, has good heat-insulating properties, decreases the fire hazard, and will take any form of interior decoration.

Gypsum Block and Roofing Tile.—Pre-cast blocks of plaster, either solid or hollow, are being manufactured at the calcining plant for the building trade. These blocks, of various dimensions and thicknesses, are used chiefly for non-bearing partition walls to insure heat insulation and fire resistance at a reasonable cost.

The roofing tile, usually reënforced with wire netting, is used chiefly as an insulation for roofs on permanent buildings. The layer of gypsum roof tile is followed, of course, with layers of roofing paper and finally the exterior ceramic roofing tile or slate. These gypsum tiles, too, are pre-cast at the calcining plant for shipment to the building trade.

Plasters.—Under this general heading may come many special plasters as well as the simple calcined product. The special plasters are demanded for special uses by the builder, the surgeon, the dentist, and the artist. However, in general the plasters fall into two groups, depending upon the manufacturing methods: (1) plasters produced by calcination of

gypsum at temperatures below 205°C., and (2) plasters produced by calcination above 205°C.

Into Group 1 fall the quick-setting *plaster of Paris*, made from pure gypsum, and *cement plaster*, a retarded plaster. This retardation may be due to impurities in the raw material or may be due to retarders added during the process of manufacture. There are many modifications of the cement plasters, among which may be mentioned the fibered and the unfibered, the sanded and the unsanded, and the special molding plasters.

Into Group 2 fall the *flooring plasters* (the *Estrichgips* of Germany) and the *hard plasters*. The flooring plasters are produced from pure gypsum by calcination at temperatures up to 260°C. The product is ground very finely and when mixed with water requires twelve to twenty hours for setting. The final product is a very hard, dense floor which has found great favor in Germany and other European countries.

The *hard plasters* are produced from gypsum by calcination at low red heat, immersion of the dehydrated product into an alum solution, drying and re-burning at high temperatures. The resulting product is finely ground and is marketed under the name of *Keene's Cement*. If sodium sulfate or potassium sulfate has been used in place of the alum, the resulting product is known as *Mack's Cement*, a product very similar in all respects to the Keene's cement. The plasters produce a very hard, nonporous surface, used extensively for wainscoatings and special floors.

Conclusion

The above brief description outlines the essential features of the gypsum industry; a rough sketch of the manufacture of useful products ended the picture. What is the future of this industry? All indications point to a rapid expansion. As the demand for better insulated homes increases (and this demand is growing by leaps and bounds even in the warm southern climates) the demand for gypsum wall board, ground gypsum, and gypsum block will increase. The added protection against the cold of winter and the insulation against extreme heat in summer are features eloquently demanding this relatively cheap insulating material. The special increase in the number of apartments in cities also demands more and more of this material. These facts argue for an increased production of gypsum products in every section of the United States.

"PERSONAL AND COMMUNITY HEALTH," BY C. E. TURNER. CORRECTION.

On page 2752 of the November issue of the JOURNAL OF CHEMICAL EDUCATION appeared a review of Turner's "Personal and Community Health," which book is published by the C. V. Mosby Co., St. Louis, Mo. The price of this book was erroneously quoted at $5.00. The correct price is $2.75.

SCOTLAND'S CONTRIBUTION TO CHEMISTRY*,†

SIR JAMES C. IRVINE, PRINCIPAL OF ST. ANDREWS UNIVERSITY, SCOTLAND

The other day a cynic said in my hearing that patriotism, if not entirely dead, had ceased to be a virtue, or at least had become unfashionable. It at once occurred to me that the countrymen of Walter Scott would be among the first to deny that statement and show that the spirit of nationality is something more than a hollow sentiment, and that such a spirit may even permeate our studies. It is with this idea before me that I select the subject of this paper. I have not approached it with any feelings of petty rivalry. I have simply endeavored to add some patriotic zeal and romantic flavor to our pursuit of scientific truth. That this national sentiment, which binds men together and preserves a continuity of purpose, may find a place in literature or art seems appropriate enough, but at first sight it appears curiously foreign to the scientist who prides himself that he belongs to a commonwealth of all men and all nations. Yet, after all, there is no departure from a lofty ideal if we cling to the feeling that we are citizens of a nation and can point with pride to the achievements of our countrymen.

Entering into this national spirit and having before my mind the subject in which we are mutually interested, I was brought face to face with the inquiry: Can we, in Scotland, claim to follow a long line of great men who have led the van of progress in chemistry from the time when it first became a science? This question, in a somewhat different form, was put to me not so very long ago by a fellow-worker who lives and labors south of the Tweed, although his method of framing the inquiry was to say emphatically: "Scotland hasn't produced any outstanding chemists, has it?" Now, such a question, when put to any Scot, might seem in doubtful taste, but when addressed to a Scottish chemist, it roused the national scientific spirit to look into the records of history and see where Scotland stands. Here, then, is the reply to my twentieth-century "sceptical chemist."

It is true that our little country, torn asunder as she was by internal strife during the Middle Ages, has left no great name to rank with that of Paracelsus or Albertus Magnus. It is also true that we did not give Priestley, Dalton, or Kekulé to the world, but it is equally true that we

* Read at the seventy-ninth meeting of the American Chemical Society, Division of History of Chemistry, Atlanta, Georgia, April 8, 1930.

† The JOURNAL OF CHEMICAL EDUCATION gratefully acknowledges its indebtedness for the illustrations used in this article as follows: to Professor LYMAN C. NEWELL, Boston University, Boston, Massachusetts, for those of Black, Dewar, Graham, Perkin, Playfair, Thomson, and Williamson; to Professor JAMES KENDALL, The University, King's Buildings, Edinburgh, Scotland, for those of Couper, Crum Brown, Hope and Young; to Mr. JOHN H. WOLFE, Consolidated Gas, Electric Light and Power Company of Baltimore, Maryland, for that of Murdoch; and to Mr. SEDERHOLM, managing director of Nobelstiftelsen, Stockholm, Sweden, for that of Ramsay.

have never been found wanting in men whose work can be ranked with the classical efforts of these great masters, men who, as thinkers, mold our thoughts today. Considering the dual nature of chemistry, which combines purely scientific thought and technical practice, we may divide our inquiry into two branches—the one to include those who have played a part in developing the theoretical aspects of the subject, the other to embrace the pioneers of scientific manufacture.

Now, for reasons already stated, we must not begin with the Middle Ages in tracing the connection between Scotland and the development of chemistry, but surely no more appropriate initial date could be chosen than that on which the Royal Society of London was founded, for this date marks the climax of the great revival of experimental philosophy with which we always associate the name of Boyle. We can claim that the first birthday of chemistry was June 21, 1662, when Charles II appended his name to the charter of the senior scientific society of the world.

Let us, however, go further back by a space of nearly fifty years. In the Matriculation Album of the University of St. Andrews there is a stained faded page containing the signatures of those who enrolled there in the year 1615, and on the third place in the list, written in a clear, bold hand, is the name Robertus Murray. It was my privilege to find this entry some years ago, and it was a source of unusual gratification to substantiate what had hitherto only been surmised, that one of the founders of the Royal Society was a St. Andrews' man and graduate. Some slight account of his life and his association with the scientific work of his time may not be out of place here, as they are by no means well known, and Murray's name is not remembered—even, I am afraid, by the Royal Society—as it ought to be. After leaving St. Andrews, he followed the natural course of the young man of spirit and went to the wars, serving an apprenticeship in Flanders, which afterward stood him in good stead in the fierce conflict of the Civil War in England. The fall of the king found Murray still in arms for young Charles, whose lot he shared during the years of exile, but at the Restoration he returned to London with an assured position, earned by long service and faithful allegiance to the Crown. Curiously enough, some trace of his old learning survived the campaigns and privations of the soldier's life. We read that he was interested in "astronomy and other philosophical works" and that he was the ruling spirit in the select band of thinkers who were then laying the foundation stones of modern science. It was his interest and personal persuasion which secured for the Society its Royal Charter, and thus the pursuit of science, and with it chemistry, first became an organized effort in this country. Within a few weeks of first seeing Murray's signature, I saw it again—more shaky, but richer in character, as is but natural when a man has both fought and lived hard. It was on the original roll of Fellows of the Royal

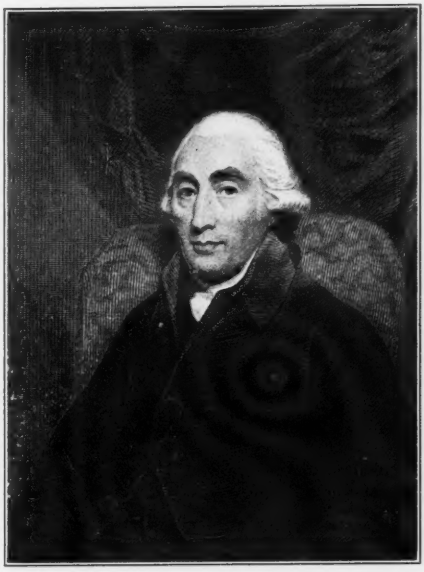
Society. His work did not stop there. For a year he acted both as secretary and president, at least he presided at the meetings, and Huyghens eulogized his efforts by describing him as the "very soul of their body." It is comforting to us as a business-like nation to find that the practical difficulties of consolidating the experimental renaissance, which commenced with Bacon, were overcome by one of our countrymen.

Meanwhile, in the sister land of Ireland, Scottish influence had also been active in promoting our subject in a curiously indirect way. No one can deny that chemistry has profited much by her long association with medicine, and the honor of having first incorporated medical teaching, including chemistry, as part of university training in this country belongs to Trinity College, Dublin. During the whole of the seventeenth century, from the first foundation of the college, this great development was gaining strength. And what, you may well ask, was Scotland's share in this movement? Turn once more to the St. Andrews Matriculation Roll. Only a few pages removed from the entry containing Murray's name there is the signature of James Fullerton, a man who played a strange part in the tangled politics leading to the union of the crowns. We find him first at St. Andrews, an undistinguished student, then settled in Dublin, ostensibly a schoolmaster, but currently reported to be a secret emissary of James VI, ready to smooth the way for the Scottish King. As the outstanding scholar of the city Fullerton was elected as the First Fellow of the new Elizabethan College. He controlled its policy in developing chemistry and medicine, a policy which finally came to a triumphant issue in the work of John Stearne, and has been adopted in every university of standing in the world.

A number of years elapse before we can again pick up the thread, but we need have no regrets for this. Remember, the progress of chemistry during the eighteenth century was in many respects painfully slow, and this we can reasonably ascribe to the hazy ideas then prevailing regarding the nature of combustion and the composition of atmospheric air. Whoever was responsible for breaking down the theory of phlogiston certainly did our subject great service, and although we must credit Lavoisier with the major share of this triumph, still, we must remember that his work was only possible through the earlier researches of Joseph Black. Further, it must not be forgotten that at least one-half of the problem of the composition of atmospheric air was solved by Rutherford of Edinburgh.

It must be admitted that our grounds for claiming Joseph Black as a Scotchman are somewhat slender; but if we do not claim him, who can? The child of Ulster Scots, born in the south of France, and educated partly in Belfast and partly in Glasgow, has a certain choice of nationality open to him; but in temperament and in blood Black was indeed a true

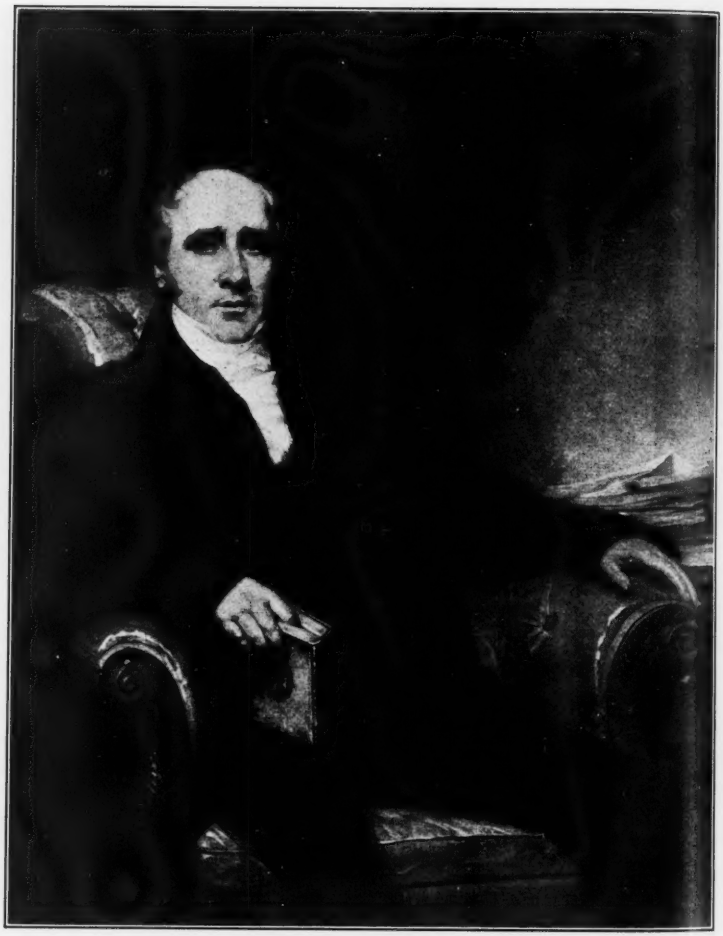
Scotchman. The whole of his work was, moreover, carried out in Glasgow and Edinburgh. It was, in fact, within the universities of these cities that the balance was first systematically used as a guide to study chemical reactions, and a new era in experimental science was commenced. If you want to know what manner of man he was who revolutionized our science, let me refer you to the account of Black's life and work given by Sir William Ramsay at the University of Glasgow on Commemoration Day, 1904. There you will find many picturesque details regarding this old-world chemist. When we reflect on his great achievements, on all that has developed from his exact methods, we must feel that if he alone stood as the champion of Scottish chemistry, we might still be proud.



JOSEPH BLACK

You know his classical research and what it led to; how that change in the weight of reacting substances enabled Lavoisier to deal the phlogiston theory a staggering blow from which it never recovered; how, moreover, it led to the recognition of the gravimetric laws of chemical change and the enunciation by Dalton of his atomic theory. These great advances were only possible by the application of two things—the continuous use of the balance and the true interpretation of the nature of combustion and of atmospheric air.

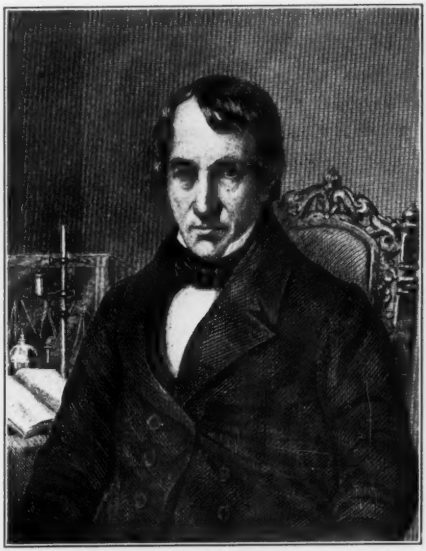
It is in connection with the latter problem that Rutherford's name comes before us again, for it was he who discovered nitrogen. From the spectacular point of view, of course, this discovery cannot rank with Priestley's isolation of oxygen. To the junior student nitrogen possesses few attractions, and I am sure the experimental lectures on this element must appear hopelessly dull—every test is negative, no positive properties are apparent. But I need not point out how, in the highest sense, the organic chemistry of today is essentially the study of nitrogen compounds, and thus really dates from the time, 160 years ago, when Rutherford carried out his simple experiments. They were crude but effective. Animals



THOMAS HOPE

were imprisoned in a confined volume of air, which was afterward washed out with caustic alkali, the gas then remaining being essentially nitrogen. The process was afterward elaborated by the use of burning phosphorus or sulfur in place of living animals, and these form familiar lecture experiments today. We have thus a direct sequence in the researches of Black, Rutherford, and Lavoisier which opened up the way to the theory of oxidation and ultimately to the atomic theory itself.

Now, as is but right and proper, we associate the atomic theory with



THOMAS THOMSON

John Dalton, but remember, it is easier to formulate a new idea than to get others to accept it. Any attempt to trace the acceptance of the atomic theory at once calls to memory the name of that Scottish chemist who vacated his Chair in Glasgow to join Joseph Black in Edinburgh. It would be fame enough for most men to have been Black's colleague and to have learned Dalton's and Lavoisier's views from personal discussion with these great theorists, but Thomas Hope's claim to our recognition rests on other and more important grounds. Himself an able experimenter, he recognized that our science could make progress only if taught by practical methods. Thus we find him, together with his assistant, Dr. Anderson, instituting a laboratory for the practical instruction of students. It is true that the claim that this constituted the first practical chemistry course in the country has been disputed, but this need not concern us, for the rival claimant is also a Scotchman.

Thomas Thomson will be remembered for two things, the willing support he gave to Dalton and his share in the foundation of student laboratories. Between 1800 and 1811 his laboratory was in working operation in Edinburgh, and, so far as I can make out, it seems to have been the first of its kind in the British Isles.

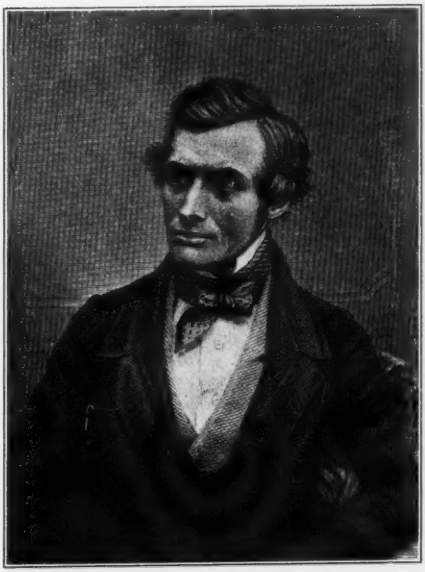
For over one hundred years the main theories of chemistry stood the test of time and, until recently, little change took place in the teaching of the theoretical aspects of the subject, save in the wealth of experimental illustration with which we embellish our lectures. Undoubtedly the greatest advance in chemical instruction lies in the position now taken by practical work. Every university, college, and school has its laboratories, and practical work is compulsory. The suggestion has even been made that we should send the lecture-room to the scrap-heap as an obsolete institution. This great movement sprang from the keen foresight of the two countrymen I have mentioned. One of them studied in St.

Andrews and became professor of chemistry in Glasgow, the other studied in Glasgow and held his chair in Edinburgh, so that three of our Scottish University centers share the credit.

No one can maintain that Scotland failed to play her part in the critical theoretical movements which took place a century ago. Dalton himself recognized that there were chemical workers and thinkers north of the Border, for it was to his friend Professor Thomson, of Glasgow, that he first communicated his atomic hypothesis and on whose advice he gave public expression to his views. Now the atomic theory gave chemistry a new lease of life. It is, indeed, hard for us to realize how crude and ill-directed were the experimental efforts made before this guiding principle was adopted, and it is no great matter of surprise to find that in scientific circles, for something like twenty years after the theory was published, the main objects of the chemist were the determination of equivalents, the correlation of these values with atomic weights, and the interpretation of the gas laws.

Then a master of experiment appeared who was destined to break away from orthodox methods and to discover a new world. I refer to Thomas Graham. His statue stands today in George Square, Glasgow, close to the magnificent buildings of the Royal Technical College, which now occupy the site of the Andersonian Institute where Graham labored at some of his best work. Even the casual passer-by must be struck by the majestic head and benevolent expression. No one who has studied his life and work can doubt that in this man Scotland gave a chemist to the world who rivaled Priestley as an experimenter and Dalton as a thinker. With the simplest of apparatus, he penetrated the mysteries of solution, diffusion, and dialysis. About eighty years ago (1849) he began his memorable work on the colloidal state of matter, work which at last in our own time is being properly appreciated. Today colloidal chemistry has suddenly sprung into a position of first importance. The subject has its own journals, a host of workers, even its own industries. It interests physicists and biologists alike; it has given us the ultramicroscope and new ideas regarding the chemical problems of life. This was emphasized by Professor H. E. Armstrong when delivering the Graham lecture in Glasgow. "It is apparent," he said, "to an extent never obvious before, that complete understanding of the behavior of colloids is an essential preliminary to an appreciation of the chemical changes which constitute life." But Graham was more than an experimenter, he was a philosopher as well. Despite the fashion of his time, he was a firm believer in the unity of matter, and who today will deny his belief? "He was a man," said Sir Edward Thorpe, "who, as no man before him had ever done, dedicated his life to the study of atoms and atomic motion." He is well remembered. The Graham lecture is a festival in his honor, and the

Graham medal for research a prize to be esteemed by all. If no one has already hailed Thomas Graham as the Scottish Faraday, let me do so now.



THOMAS GRAHAM

And now, as we review the leaders of thought and action whose span of life almost overlaps with our own, our thoughts are arrested by one of Graham's outstanding pupils. In the year 1833 two brothers matriculated in St. Andrews, where their grandfather had been principal of the United College. They were George and Lyon Playfair. Scientific research evidently found in them willing victims, judging from the fact that we hear of their disappearance one day and their subsequent discovery in the kitchen regions where George was boiling a sparrow to obtain the skeleton, while Lyon was endeavoring to prepare sugar from beetroot. There are many points of interest connected with Lyon Playfair's subsequent career. In Glasgow he was a fellow student under Graham with David Livingstone, the explorer, and with James Young, the founder of the Scotch paraffin oil industry. Among his many romantic experiences in later life, one was to lecture to the veteran John Dalton in Manchester. If Playfair's original scientific discoveries were few, his scientific influence was truly enormous. We need his like today. He was one of the first to attempt the fusion of manufacturer and scientist, and he cast everything he held most dear into the crucible to make this valuable alloy. One of the products was the 1851 Exhibition; another, the valuable research scholarships which are financed out of the surplus from that venture, for it was Playfair's influence which prevented the money being squandered in the erection of a popular museum. Out of 429 appointments made to the Scholarship between 1891 and 1915, no fewer than 219 were allotted to the subject of chemistry, and inspection of the latest report issued by the Commissioners shows that almost without exception these scholars now occupy important positions either in the teaching of the subject or in industrial work. The scheme was the first of its kind

LYON PLAYFAIR

to be established in this country, and its success has not only given a great impetus to the study of science in the universities, but has inspired other endowments of a similar nature, notably the Carnegie Trust for the Universities of Scotland, and the Government Department of Scientific and Industrial Research. Add to this the fact that Playfair was, in addition, one of the founders of the Chemical Society of London and you can form some small idea of the potent influence of this Scottish chemist.

I have spoken already of the debt chemistry owes to the learned societies, and have referred in this connection to the Royal and Chemical Societies. To these we must add one other, the British Association for the Advancement of Science. It is the custom in some quarters to depreciate the work of this body on the score that during the meetings the holiday spirit overrules the scientific. But we must not forget that the Association has been one of the most important factors in creating a scientific atmosphere in this country. The success of the venture may be gaged from the fact that the scheme has been copied by America, Australia, and Germany. Chemists have figured among the presidents and chemical research is subsidized directly from its funds. Halt for a moment, then, in the nineteenth century and inquire how the Association came into being. Nearly a century ago a group of earnest scientists sat round a table and discussed how their work could be incorporated with a popular movement. Sir David Brewster, who, in succession, was principal of the United College, St. Andrews, and of the University of Edinburgh, was one of the most active members of that band, and thus Scotland can claim the high honor of being concerned in the foundation of three great scientific societies.

Now, the organic chemist has no doubt recognized by this time that our rapid survey has brought us to the early days of this branch of the science. Looking back through eighty years, Wöhler, Liebig, Bunsen, and

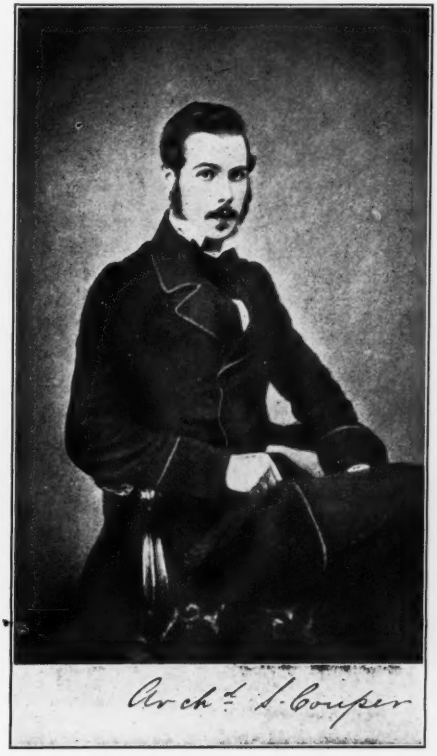
ALEXANDER WILLIAMSON

Kekulé occupy the summit of our imagination, and at first sight there seems no room for any of our brethren. Look a little closer and two figures stand out boldly in pathetic relief.

One is Alexander Williamson, nearly blind and partly deformed; the other is Archibald Scott Couper, to whom Providence gave a heavy burden. Let me briefly tell their story. Williamson, though born in Wandsworth in 1824, was of Scottish parentage, so that we need have no hesitation in adding him to our list. Delicate from boyhood, he suffered throughout his life from feeble sight and a withered arm—you can imagine what handicaps these were in laboratory work. His student course was taken out under Graham, Gmelin, and Liebig, and at its conclusion he was induced to apply for the Chair of Chemistry in University College, London, when vacated by Fownes. It is interesting to note that it was Graham who strongly advised him to take this step, and the report of the inaugural

lecture states that the young professor was warmly complimented by the venerable Scottish chemist who had been so largely responsible for the appointment. Most of us know the part played by Williamson in helping organic chemistry over the early difficulties; but let me draw your attention to some other features of this man's activities which are not so well known. For one thing, he threw himself wholeheartedly into the development of the University of London as a center of chemical study. His father had in fact been one of the founders of University College, and the son nobly continued his work. He instituted a Faculty of Science and was the first to introduce chemical study for engineers. When you think of the magnitude and influence of the University of London, especially of its various chemical schools, and of the high position taken by the metropolis in this subject of ours, then you will see that "Scotland's contribution to chemistry" is not provincial. Chemistry, through Williamson's agency, permeated London more thoroughly than ever before, and more than that, we may even regard this man as the missionary of science to the Far East. In 1863 five young Japanese noblemen, leaving their own country at the risk of their lives and under assumed names, arrived in England to join Williamson's laboratory. They took back with them the seeds of Western scientific culture, and the harvest has been modern Japan. One of these young chemists was the Marquis Ito, and the mere mention of that name speaks sufficiently for Williamson's claim to be included in our roll of honor.

Although there are many points of similarity between Williamson and Couper, they present a sharp contrast in respect to the positions they achieved in fickle memory. Despite physical disabilities, Williamson, as we have seen, was prominent throughout his life; placed in the foreground, his work and character were known of all men. What a different story was that of Couper! In 1858, three papers from the Paris laboratory appeared in the *Comptes rendus* over the signature of A. S. Couper. Two were experimental on some derivatives of benzene and on salicylic acid, the third was purely theoretical and dealt with the structure of carbon compounds. It aroused intense interest; then, with startling suddenness, the record comes to an end, and Couper passes into the outer darkness of oblivion. That the theoretical paper referred to included a hypothesis to all intents and purposes identical with that of Kekulé was fully recognized, but as no one was acquainted with Couper's previous or subsequent history, as his very nationality was unknown, his name was speedily forgotten. It remained for a German chemist, Richard Anschütz, to claim for Couper the recognition as a master of theory, which has been too long delayed. No finer example of the universal brotherhood of science can be cited than the effort made by Anschütz to do justice to the memory of an obscure stranger to whom he owed



nothing, not even national sympathy. Several years ago, Anschütz was induced to repeat Couper's experiments on salicylic acid, the results of which had been disputed, and even rejected, as unsound. At every stage he found the work reliable, and he then set himself the task of tracing step by step the career of this unknown man whose name had flashed meteor-like across the sky in 1858, and had been so dramatically eclipsed. In this work he received invaluable help from the eminent Edinburgh chemist, the late Professor Crum Brown, and here is the story they jointly tell in the *Proceedings of the Royal Society of Edinburgh.*

Couper was born in Kirkintilloch, near Glasgow, in 1831, and undertook a curious student course, devoting himself almost exclusively to philosophy, alternating, apparently at random, between the Universities of Glasgow and Halle. His resolve to take up chemistry seems to have come as an inspiration, for we find him suddenly dashing off to Paris to study with Wurtz. Within three sessions of first joining the laboratory he commenced research, and only cruel ill-fortune deprived him of the honor of being the father of structural chemistry. Early in 1858 he sent his paper "On a New Chemical Theory" to the French Academy of Science. It was certainly in the hands of Adolphe Wurtz before May 19th, a date which becomes important in view of subsequent events. But Wurtz seems to have hesitated in his decision to recommend the paper for publication in the *Comptes rendus* and it was the month of July before it appeared under the patronage of Dumas. Meanwhile, the issue of *Liebig's Annalen,* which appeared on May 19th, contained Kekulé's classical paper, "*Uber die Constitution und die Metamorphosen der Chemischen Verbindungen und die Chemische Natur des Kohlenstoffs.*" Couper was forestalled through

no fault of his own. In all fairness to Kekulé, it must be admitted that he treated Couper's theory, which was a distinct advance on his own, with generous appreciation, but he adhered rigidly to the relative dates of publication, and claimed priority for himself. Couper made little or no attempt to uphold his position. The outer world heard no more of him, yet, today it is his system, rather than Kekulé's, which enables us to build up these stupendous structural formulas which are at once the terror of the uninitiated and the delight of the true organic chemist. His subsequent history is doubly tragic in view of what was denied him. His health broke down within a few months of the appearance of his paper, and, while convalescing, he suffered a severe attack of sunstroke which enfeebled him for the rest of his days. At his old home in Kirkintilloch, tended with loving care by his mother, he lingered until 1892, living unknown, while in every university in the world his theory was being taught as one of the finest working hypotheses of our time. It is not a happy story, but at least there is satisfaction in knowing that justice to his memory has at last been done. "Truly," as Anschütz says at the end of his memoir, "Archibald Scott Couper deserves a place of honor beside his more fortunate fellow-worker, Friedrich August Kekulé."

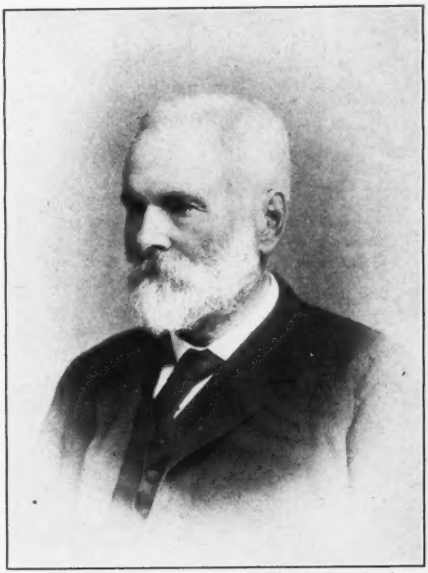
When we come to our own times and reflect on the progress made through the structural study of organic compounds, all chemists will agree that we owe much to the instinctive genius of Crum Brown. His rare mind was not content with the haphazard methods of substitution in the benzene series, and his generalizations did more than we can well appreciate to elevate this branch of synthetical chemistry into an exact science.

This is not a bibliography of famous Scottish chemists but a serious attempt to show that this part of the country has excelled in producing leaders of thought capable of giving chemistry a new impetus. Were I to include also a recital of isolated important discoveries which were initiated by Scots the list would be endless, and would contain no more striking case than Frederick Guthrie's first preparation, made in Edinburgh 68 years ago, of the deadly compound now known as "mustard gas." Many dramatic stories might be told of such discoveries, but I turn to remind you that chemistry is passing through a period of change, due to the striking advances made recently in physical research. Here again we have no unworthy record, and the name of yet another Scottish chemist is engraved on the wall of Westminster Abbey.

Sir William Ramsay opened up a new world by his discovery of the inert gases, and the manner in which his results prepared the way for the study of radioactivity and for new ideas regarding the structure of the atom, commands the highest admiration. His name will be remembered wherever chemistry is known, and we must remember also that he hailed

from the Firth of Clyde.

For many reasons the work of chemists whose time overlapped with our own is referred to but briefly in our review, yet I cannot pass to the second aspect of my subject without reference to Sir James Dewar's heroic efforts to study the properties of matter in the neighborhood of the absolute zero. Again, it is a case of pioneer work, and the achievement is due to one who was born on the banks of the Forth, and studied in the University of Edinburgh.



Elliott & Fry, London

ALEXANDER CRUM BROWN

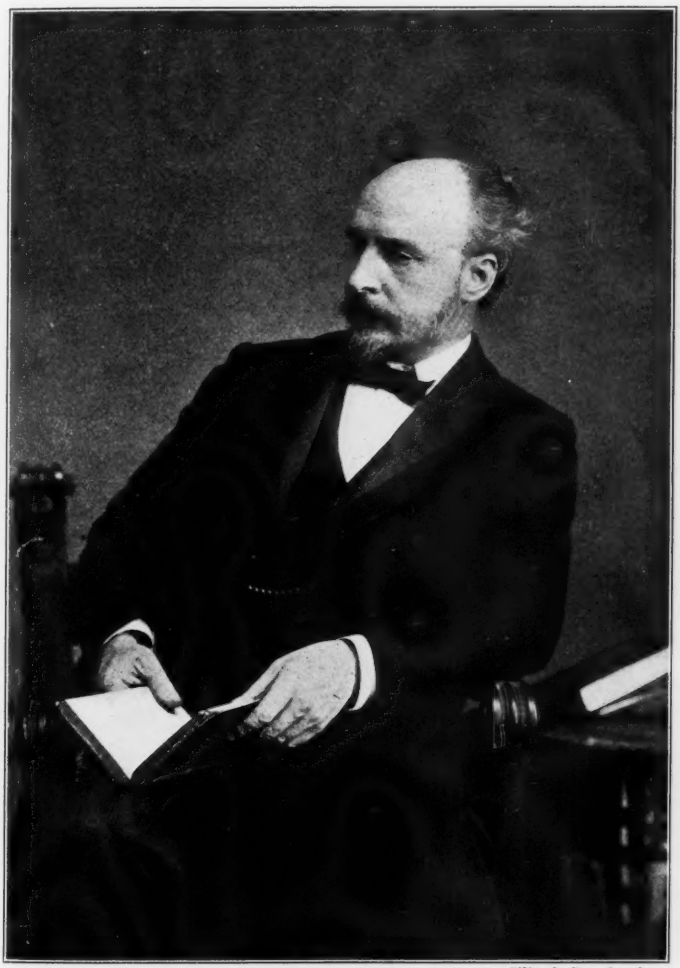
If we turn now to the second aspect of our inquiry, the influence of this country on the history of chemical manufactures, the prospect seems at first sight far from encouraging. Today we have no firms in Scotland which can compare with the Badische Anilin und Soda Fabrik, and in the past no name may occur to us of men who, like Perkin, senior, or Ludwig Mond have given the world new industries of colossal magnitude. Look a little more closely into the position, however, and we find that Scotland is by no means discredited by the position she takes as a manufacturing center, and as the birthplace of new and important chemical industries. Bound up as our manufacturing interests must of necessity be with our coal and iron supplies, it is not surprising that we can lay claim to many of the metallurgical processes which have revolutionized this branch of industry. The introduction of the hot blast in the manufacture of pig iron, patented and first used by James B. Neilson, the chemist of the Clyde Iron Works, will stand as one of the many examples which may be cited, but I wish to avoid trespassing into metallurgy, which until quite recently was too empirical to be classified strictly as a science.

It is difficult to know where to make a start in our inquiry as few records exist of early chemical manufactures, and the processes developed more or less independently of the growth of pure science, but it was once the case that a good idea of the standing of a country in chemical industry could be

William Ramsay

gained by comparison of its position in the alkali trade. Applying this test to Scotland, we have to go back to the days of James Watt, the engineer, for it was he who brought the news to Glasgow that Berthollet had obtained a fluid possessing powerful bleaching properties by passing chlorine into caustic potash. He communicated this news to his friend, Charles Tennant, who improved on the process by the substitution of slaked lime for the soluble alkali, and took out the first patent for the manufacture of bleaching powder in 1798. The direct outcome of this new venture was the erection, also by Tennant, of a sulfuric acid plant at his Glasgow factory in 1803. The same year saw the first technical preparation of soap commenced by the same firm. Thirty years later the Leblanc process was adopted, and thus we see Scotland in the foreground as a producer of all the various products of the alkalii ndustry. However, one may regret the gradual absorption of the old Scottish firm, this cannot entirely destroy our satisfaction in thinking of the endless discoveries emanating from Scotland which did so much to keep the alkali industry in this country for the space of nearly a century.

It is interesting also to notice that Scotland led the way in the process of "destructive distillation." As Professor Henderson said in a report to the British Association: "The problem of how to distil a carbonaceous material most economically has been solved in Scotland." We need not be surprised at this, considering our national reputation for economy. The beginning of the many industries which depend on destructive distillation is found about the middle of the eighteenth century, when Bishop Watson described in his "Chemical Essays" the preparation of coal gas. It was left to a Scotchman, William Murdoch, to expand the idea into a large-scale process, and to illuminate first his house, then a small factory, and ultimately London itself by means of coal gas. The process of destructive distillation was spreading all over the country at the beginning of the



Elliot & Fry, London

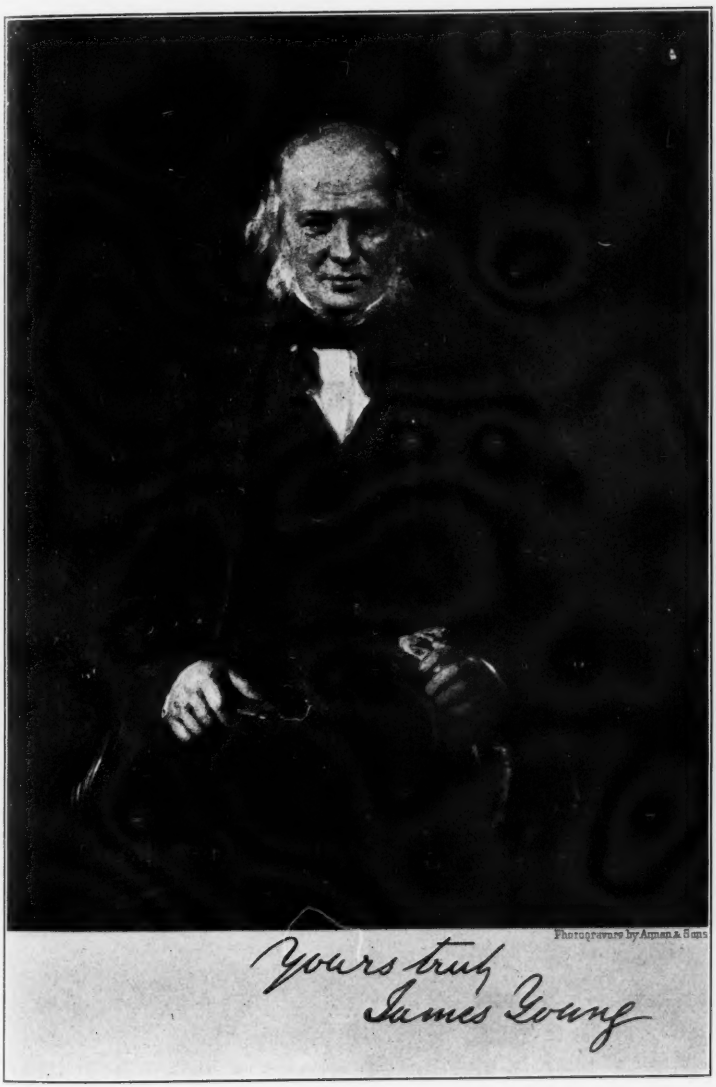
SIR JAMES DEWAR

WILLIAM MURDOCH

nineteenth century. In 1806 it was applied to wood by another Scot, named Turnbull, and a factory producing charcoal and acetic acid was erected at the Vale of Leven. But Scotland's greatest triumph in this field is found in the work of James Young, of Kelly, and his successors in promoting the paraffin industry.

Paraffin products have always been valuable, at no time more than today, owing to the growing use of the internal combustion engine. In America and some other fortunate countries the crude oil escapes freely from the oil wells, and has only to be collected, purified, and refined. Scotland has no natural oil deposits, and James Young, a pupil of Graham, had to dig deep in the earth for his raw material. The bituminous shales yielded crude paraffin oil when destructively distilled, and out of this fact he made an industry. But the Scotch manufacturer has to mine his material, raise it to the surface, and carry out a tedious distillation before he is on an equal footing with his American competitor. The yield is small, only 12 per cent of the weight of the shale; but, step by step, the process has been improved and economies effected until, just before the war, the cost of handling the mineral from the pit, until, as ash, the exhausted residue was dropped on to the waste heap, was no more than 2 s. per ton. The honor we ascribe to Young is in great measure shared by Sir George Beilby, who came to the rescue of the process during a period of stress in 1881 by introducing an improved method of extracting all the nitrogen in the form of ammonia. The whole story is a great triumph for that most excellent blend, Scottish perseverance and the scientific method. Talking of this combination, another striking example occurs to me, where the two virtues (embodied in two remarkable men) were happily united.

One of these men was William Henry Perkin, the discoverer of aniline dyes, and the other Robert Pullar, of Perth. It would take too long to describe how Perkin, confident that he held the secret of a valuable industry in his hands, was baffled and discouraged by the unsympathetic and critical attitude of the dyers. The new process was too difficult, too uncertain, too costly. It would probably have lapsed entirely, but for-


Photogravure by Annan & Sons
Yours truly
James Young

tunately he sent a skein of silk colored with the new mauve dye to Robert Pullar, who wrote back at once, "If it is possible to apply that in a practical way, it will be a very valuable thing." The invention was taken up and applied in Perth, and thus the process was saved, not, alas, for Scotland.

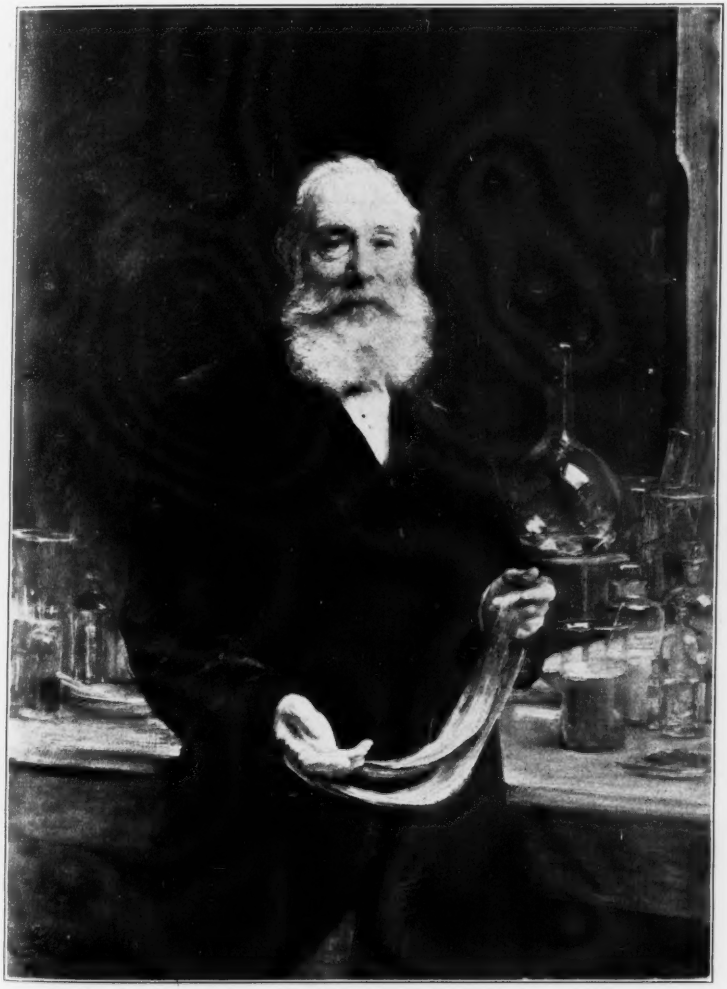
I think I may reasonably omit all reference to chemical manufactures where, strictly speaking, we have not played a pioneer part, and mention only in a word two practical monopolies obtained for Scotland, the manufacture of the dichromates by the Whites, and of the borates by Joseph Townsend. These involve processes which, although carried out almost exclusively in Scotland, were not first developed here, and thus have little place in a review of this kind.

Turn, however, to a new industry which has arisen in our own times, the manufacture of cyanides. Forty years ago the use of potassium cyanide was restricted to electroplating and photography. The world's production did not exceed fifty tons per annum, and the price was 4 s. 6 d. per lb. The discovery of the cyanide process for extracting gold immediately created a new situation, and a rush was made to secure patents for the production of the salt in large quantity. For some time it looked as if Germany would secure the prize, as one of the Rhine firms "cornered" all the sodium produced by Castner's method, but once more Scotland gained the day. Sir George Beilby, to whose inventive genius I should like to pay a tribute, patented a process in 1891 in which potassium cyanide is prepared by the action of ammonia on a heated mixture of potassium carbonate and carbon. Within five years the process was producing over a ton a day of the product at a price of only 10 d. per lb.

Other examples equally instructive might be quoted. I should like to refer to the days when Scotland's kelp industry fought the Milan Decree of Napoleon, and to Standford's heroic effort to conduct kelp manufacture on scientific lines, but possibly I have said enough to make good my case.

One feature is, however, lacking in Scotland's record as a manufacturing country. Despite the great variety of the compounds produced, they belong almost entirely to the category known as "heavy chemicals." It is true that four out of the eight branches of Nobel's Explosives Company are situated in Scotland, but, at the most, we can merely claim that these industries have found a home here. They are not, strictly speaking, our own. The somewhat melancholy fact remains that from the port of Glasgow we ship our heavy chemicals, while Leith normally receives large consignments of the so-called fine chemicals.

There are bright exceptions to this generalization. For long the city of Edinburgh has been a center for the manufacture of drugs. It is something to be proud of that the scientific extraction of alkaloids was developed



SIR WILLIAM PERKIN

here, and is still an important local industry. Again, every one remembers Simpson's dramatic discovery of the use of chloroform as an anesthetic, but few realize the skill and enterprise of the Edinburgh manufacturers who prepared the chloroform for the first experiments, and have since been among the principal manufacturers and distributors of the material.

And now in conclusion let me ask: What lesson can we draw from a mere recital of all that this little land has given to our science? We must believe that there is a national aptitude for certain forms of thought, and with this unbroken line of great men behind us, we must feel that it is part of our inheritance to possess some power to advance the subject of chemistry and to leave our imprints on its records. The men whose names have passed in review before us enjoyed no greater privileges and facilities than we do ourselves. Their characteristics, with few exceptions, were those which are typical of our race. Industry and enthusiasm, Scotch caution and philosophic daring, dogged perseverance and a certain disregard of public opinion, combined to bring them to their triumphs. This record of Scotland has to be maintained; men must be found who can take the place of Ramsay, Playfair, Graham, and James Young. The responsibility must inspire us in our work to know that our race does possess the peculiar talent which marks the leader of scientific thought. It is well to keep this before us, for the world often forms narrow judgments. Listen to what Liebig said after his famous journey to Britain: "I have traveled through England, Scotland, and Ireland, seeing much, but learning little. England is not a scientific country." How premature and inaccurate was that opinion, uttered in 1837, you will gather when you remember that Davy was but lately dead, Dalton was still alive, Graham was in Glasgow, Playfair was studying at St. Andrews, Williamson, Couper, and Young were boys at school.

Think of the verdict of another philosopher in summarizing the "History of European Thought in the Nineteenth Century." I quote from Merz, who says: "The largest number of scientific publications, perfect in form, classical for all time, probably belongs to France: the greatest bulk of scientific work to Germany; but of the new ideas, which during the century have fructified science, the larger share belongs to England." It has been my endeavor to associate Scotland with England in this expression of well-earned praise.

"FEEDING THE FAMILY," BY MARY SWARTZ ROSE. CORRECTION

On page 2753 of the November issue of the JOURNAL OF CHEMICAL EDUCATION the author of the book "Feeding the Family," published by The Macmillan Company, was erroneously given as MARY SWARTZ. The name should have read MARY SWARTZ ROSE.

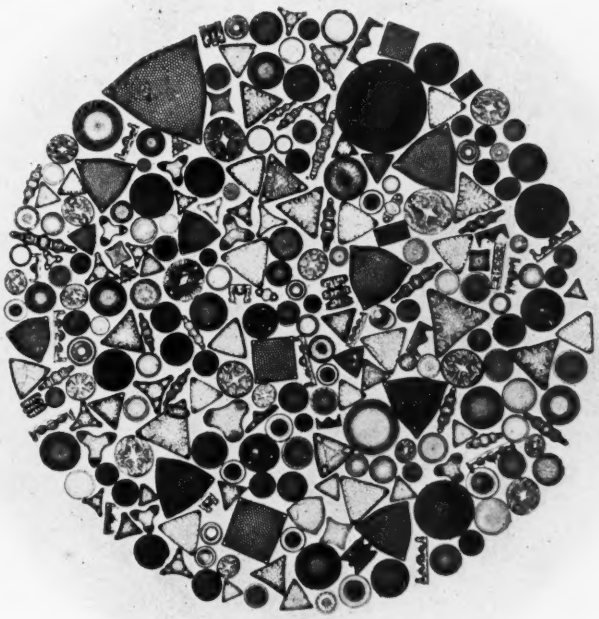
DIATOMACEOUS EARTH

ROBERT CALVERT, VAN SCHAACK BROS. CHEMICAL WORKS, CHICAGO, ILLINOIS

Diatomaceous earth is one of the most widely used and least understood of all materials of chemical industry (*1*).

Origin

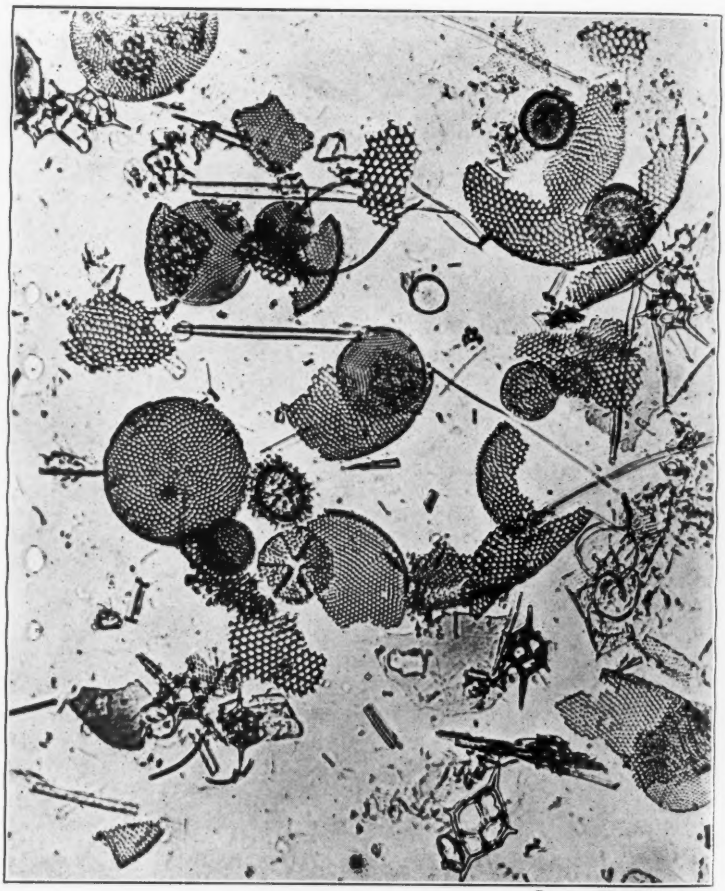
Diatomaceous earth contains the siliceous remains of innumerable diatoms, microscopic unicellular aquatic plants closely related to the Brown algae.



Courtesy Dr. Albert Mann

FIGURE 1.—PHOTOMICROGRAPH OF DIATOMS REPRESENTED IN DEPOSIT AT OAMARU, NEW ZEALAND

Wherever water and light have coexisted for a sufficiently long time, diatoms may be very abundant. In the oceans, they serve as food for the lower forms of sea life, upon which in turn the higher forms feed. For this reason, diatoms have been called the "grass of the sea." It has been



Courtesy The Celite Co.

FIGURE 2.—LOMPOC (CALIFORNIA) DIATOMACEOUS EARTH × 230

This earth is much used as a filter-aid, a thermal insulator, an addition to concrete, and as a filler.

The diatoms here represented by their frustules are marine, plankton (floating) types. They include *Actinoptychus undulatus Ralfs* (circular, with six sectors), *Coscinodiscus excentricus E* (discoid), *Coscinodiscus marginatus* (discoid with heavy margin), and the rod-like *Synedra* (*Thalassisthrix*) *Nitzschioidus Grun*. The burr-like objects with four or six arms are not diatoms but cilia of animals.

estimated (*2*) that the annual yield of diatoms below an acre of surface of the English Channel off Plymouth amounts to five and a half tons.

Under the microscope these tiny plants are objects of great beauty. Each of the eight thousand and more species has an ornateness and symmetry of skeleton that differs from that of every other species. The skeletons are of the form of crescents, discs, rectangles, triangles, varipointed stars, boats of gossamer, or various geometric figures. Although so small that some fifty million of them may be present in a cubic inch, the particles have not only shapes but also surface adornments that are char-

TABLE I

Analyses of Diatomaceous Earths of the United States

Location	*Herkimer Co., N. Y.*[a,d] %	*Richmond, Va.*[e] %	*Wilmont Wharf, Va.* %	*Pope's Creek, Md.*[f] %	*Clermont, Fla.*[g] %	*Ellensburg, Wash.*[h] %	*Fossil Hill, Nev.*[i] %	*Lompoc, Cal.*[j] %	*Monterey, Cal.*[i,k] %	*Pit River, Cal.*[l] %
Water.....	12.12	8.37	3.40[b]	3.47	...	5.98	5.99	5.00	4.89	...
Silica.....	86.51	75.86	82.85	81.53	98.43	84.91	86.90	89.30	86.89	96.02
Alumina.....	0.45	9.88	6.76	3.43	...	1.75	4.09	4.00	2.32	1.03
Iron (Fe_2O_3).	0.37	2.92	2.34	3.33	...	2.04	1.26	0.70	1.28	0.62
Lime (CaO)..	0.12	0.29	0.35	2.61	...	0.11	0.14	0.40	0.43	0.12
M'g'sia(MgO)	0.42	0.69	1.06	5.63	...	0.19	0.51	0.40	Trace	...
Miscellaneous	...	0.94	3.15[c]	...	...	4.94	1.18	0.20	3.58	...
Total.....	*99.99	98.95	99.91	100.00	98.43	99.92	100.07	100.00	99.39	97.79

[a] Water-settled to remove clay prior to analysis.

[b] Includes "loss on ignition."

[c] Includes "Soda, 0.99 per cent; Potash, 1.07 per cent; Titanium oxide, 1.09 per cent.

[d] *N. Y. State Museum, Ann. Rept.*, **57**, 1, Sec. i, 171.

[e] WATSON, *Mineral Resources Va.*, **1907**, 218.

[f] *Calif. State Mining Bur. Bull.*, **38**, 289 (1906).

[g] C. LINDLEY WOOD, Private Communication.

[h] S. A. MILTON, Private Communication.

[i] ARNOLD and ANDERSON, *U. S. Geol. Survey Bull.* **315**, 445; from *Calif. State Mining Bur. Bull.* **38**, 28 (1906).

[j] THATCHER, U. S. Patent 1,477,394 (1923).

[k] LAWSON and PASADA, *Univ. Calif. Dept. Geol. Bull.* **1**, 25.

[l] ROOT, *Calif. Bur. Mines*, **22**, No. 2 (1926).

acteristic for the various species. There are elevations, depressions, pores, canals, wave marks, radial lines.

As different as the thousands of species appear under the microscope, all diatoms are alike in building a skeleton that is substantially pure silica and in secreting a droplet of oil. On the decay of the diatoms, the oil and the silica remain. Occasionally the conditions of growth, wind, or current favor the settling of the silica into great deposits that are only slightly contaminated. A similar concentration of diatom oil, either the

primary oil or oil formed by decomposition of the vegetable matter of the diatom, is possibly responsible for much of our petroleum (*3*), (*4*), (*5*).

Occurrence of Diatomaceous Earth

Deposits of fossil diatoms occur in hundreds of localities. Many of these deposits are extensive and rather free from excessive contamination by impurities.

Thus the deposits at Lompoc, California, cover several thousand acres to a depth of about a thousand feet. The best strata have a purity that exceeds ninety-three per cent of silica. Other extensive and useful deposits occur in California, at Bradley (near Monterey), at San Pedro, and along the Pit River, in Oregon, Washington, Nevada, Florida, Maryland, Virginia, New Hampshire, New York, and other states. In foreign countries, noteworthy deposits are those in Algeria and Germany.

The various deposits differ not alone in species of diatoms represented but also in the amount of clay, sand, and other impurities present. The degree of contamination of various deposits in the United States may be judged from the data of Table I. (See page 2831.)

Great caution should be exercised in investing in diatomaceous earth. Only a few of the best deposits in the United States pay a reasonable return upon the capital invested. Also, there is being built up a patented art that makes increasingly difficult the lot of new entrants in the industry.

Names for Diatomaceous Earth

In combining in one substance the properties of microscopic size of particles, a high degree of porosity, low density, chemical inertness, and refractoriness, diatomaceous earth is unique. Hence, its industrial applications are expanding rapidly.

This increase in use is not recognized generally, because the earth is designated by its true name almost never and by confusing trade names practically always.

Although ninety per cent of our cane sugar, in being refined, is submitted to filtration through diatomaceous earth, the sugar refiner or other user of filter-aid buys diatomaceous earth not by its right name but as "Diatomite," "Filter-Cel," "Super-Cel," "Filter-Pac," "Dicalite," "Suma-Sil," or other names that effectively disguise the nature of the material being used. The same applies to thermal insulation. The boiler setting or furnace operating at high temperature requires an insulator of the refractoriness of diatomaceous earth. The engineer installs diatomaceous earth as powder, granules, blocks, or bricks but calls it "Sil-O-Cel," "Non-Pareil," "Armstrong Brick," "C-3," "Diatex," "Feather-Stone," "Super-Brick," etc. As used as an admixture to make concrete more workable and uniform during handling and pouring and also better

after setting, diatomaceous earth is commonly known as "Celite" or "Plastic-Pac" or by one of the names previously given. Still other names are resorted to for those who use diatomaceous earth as a filler or as an ingredient of polishing and cleansing compounds, as for lacquered automobiles.

Various names are used abroad. Of these the most common perhaps are kieselguhr and infusorial earth. The former means a flint-like sediment and, although rather comprehensive, is correct to the extent that diatomaceous earth shares with flint the property of being a siliceous residue. The name infusorial earth is entirely incorrect. The name originated nearly eighty years ago, when Professor Ehrenberg (*6*) erred in believing that diatomaceous earth comprised skeletons of unicellular animals called *Infusoria*. We know now that *Infusoria* do not form deposits, also that diatomaceous earth is of vegetable, not animal, origin.

Fuller's earth, Bentonite, and colloidal clay, on the other hand, are clayey materials just as different from diatomaceous earth as clay should be from a nearly pure silica.

Statistics of Production

Since diatomaceous earth is seldom sold to the users by its right name,

TABLE II

World Production of Diatomaceous Earth—Long Tons*

	1922	*1923*	*1924*	*1925*	*1926*
Algeria	2,480	10,000	9,092[b]	8,343[b]	7,931[b]
Australia—New South Wales	489	523	573	712	926
Canada	199	118	30	nil	60[d]
France	4,620	4,550	2,300	1,500	2,982
Germany (exports)	5,207	4,096	4,326	4,555	5,919
Ireland (northern)	1,909	1,680	2,480	3,343	2,975
Italy	175	420	420	420	1,200
Japan	4,690	5,319	5,040	4,727	[a]
Norway (exports)	82	110	67	48	57
Sweden	322	696	608	819	[a]
Union of South Africa	[c]	217	236	...	[a]
United States	40,606	59,722	57,300	66,251	79,039

[a] Data not available.

[b] Exports.

[c] Quantity not reported; value $9277.

[d] Mined but not shipped.

* Imp. Mineral Resources Bureau, Great Britain, Statistical Summary, **1920–1922,** 85; *ibid.*, **1923–1925;** Statistics, "Diatomaceous Earth," **1919–1921,** 1.

KATZ, U. S. Bureau Mines, Mineral Resources U. S., **1925,** II, 176.

JONES, U. S. Bur. Mines, Mineral Resources U. S., **1926,** II, 177–8.

FURNESS, Commerce Reports, Oct. 15, 1928, 177–8. Also, U. S. Dept. Commerce, Private Communication.

EARDLEY-WILMOT, Can. Dept. Mines, Rept. 691, "Diatomite," **1928.**

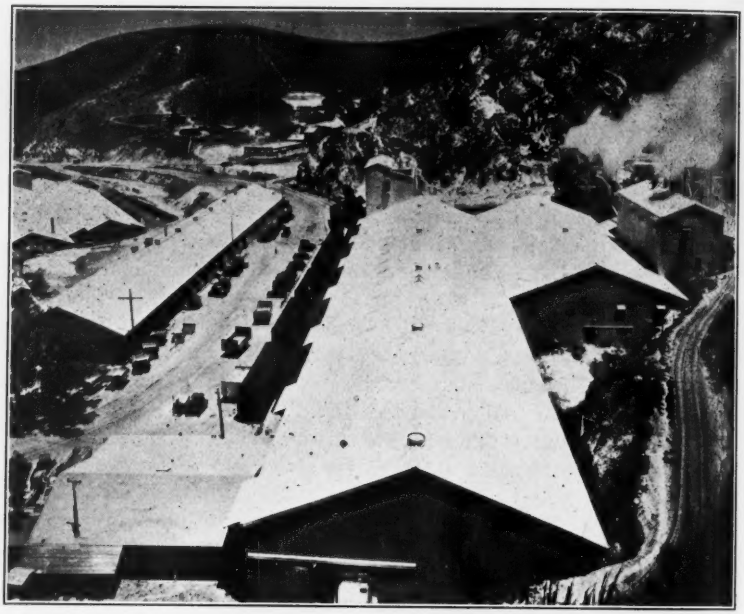


FIGURE 3.—MILL OF THE CELITE CO., LOMPOC, CALIFORNIA
Research laboratory in the central background and diatomaceous outcrops in the hills.

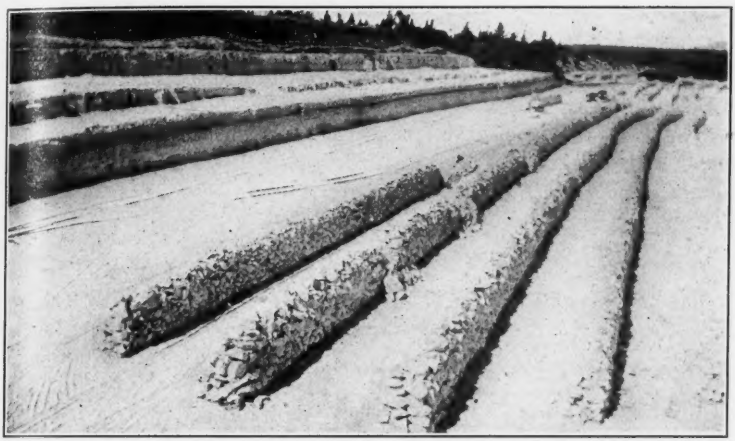
it is all the more surprising that the consumption of the material in the United States has increased approximately thirty-fold in the last thirty years. Figures for the year 1929, when published, may show the United States production to have been between 100 and 140 thousand tons. Data for earlier years are shown in the tabulation of world production, in Table II.

The supremacy of the United States in the industry of diatomaceous earth is due probably to three causes: the remarkable quality of deposits in the states of Washington, Oregon, Nevada, and California; the size of the consuming industries in the United States; and the efforts expended in this country in research to develop new products and uses. Several of these reseaches have already had most favorable effects upon the industry.

Mining of Diatomaceous Earth

Diatomaceous earth is obtained by dredging at Clermont, Lake County, Florida, and by underground tunneling and stopping at Carlin, Elko County, Nevada. The usual method, however, is that of quarrying.

The method of quarrying may be illustrated by published descriptions of the operations at Lompoc, California. The overburden is removed



Courtesy the Atomite Corp.

FIGURE 4.—QUARRYING DIATOMITE FROM THREE SUCCESSIVE LEDGES 1000 FEET LONG
In the central background, a steam shovel removing overburden. In the foreground, a drying field.

by power shovel, scrapers, or by dragline excavator. The layer of diatomaceous earth thus exposed may be twenty feet or more in thickness. The diatomaceous stratum is then checker-boarded with a chain saw. Parallel kerfs are cut about four feet deep and four feet apart in each of two directions, one direction making a right angle with the other. Since the diatomaceous rock parts easily along bedding planes parallel to the surface, the rock, in the various squares formed by sawing, is easily severed by a horizontal blow with a miner's pick.

The slabs so produced are loaded onto wagons, hauled to an open, sunny field, stacked in parallel rows, as illustrated in Figure 4, and left for three to eight weeks to dry. During this drying period, the percentage of water in Lompoc rock will be lowered from the original forty-five per cent to less than ten, usually about seven, which is permissible in the product as marketed.

Atmospheric drying, as described above, is now being replaced largely by forced drying at elevated temperatures.

Preparation of Diatomaceous Earth for the Market

Leading manufacturers offer several grades of material—powder, granules, bricks, or blocks. Any of these products except blocks may be natural or calcined. Calcining, when used, removes water of hydration and induces partial sintering, of the clay at least.

To make the powder, dried diatomaceous rock is pulverized to the degree desired. Super-Cel, a high-speed filtration powder, is made by calcining

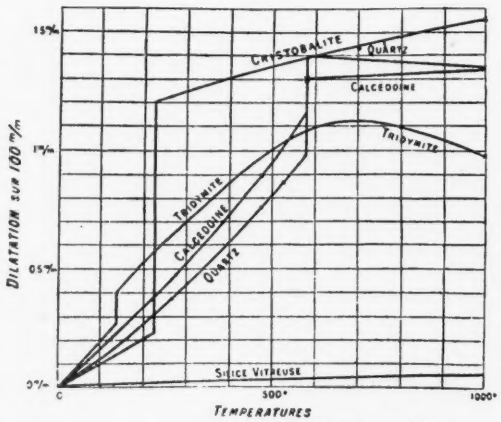
powder of excellent quality, either alone (7) or in the presence of chemicals (*8*), (*9*).

To make granules, there is used dried or calcined rock, as, for example, rock that has been fired at 1000°C. This is cracked and then screened to the size desired. Oversize material is returned from the screens to the granulating mill. A common variety is that which is 3-mesh or finer and is sold as C-3.

Bricks

Diatomaceous bricks are made in two distinct ways.

The bricks may be sawed to shape from diatomaceous rock. This was done formerly by circular saws to which were brought blocks of severed diatomaceous rock. Now these bricks are being sawed, at the rate of tens of thousands a day, by saws which move continuously along the quarry and cut the bricks to shape while still a part of and firmly held in the face of the quarry. These brick saws, invented by Starr and Marsh (*10*), are illustrated in Figure 5. After being sawed, the bricks are then dried or calcined (*11*).

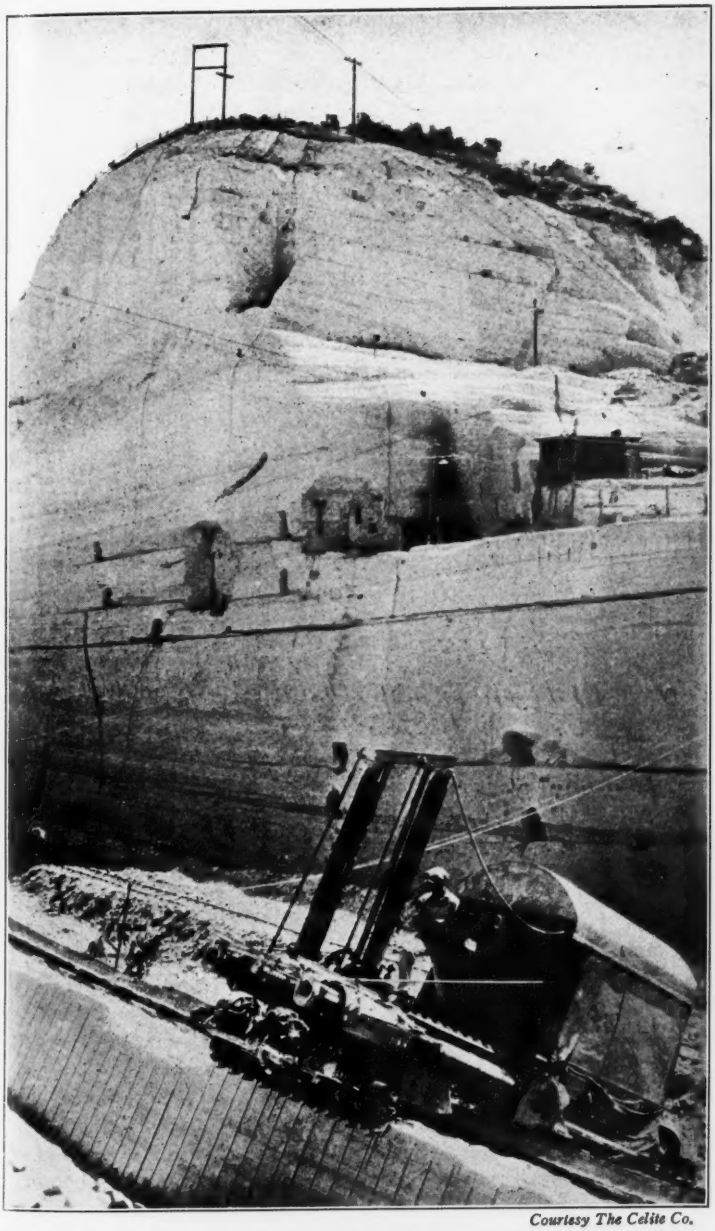


After Washburn and Navies

FIGURE 6.—THERMAL EXPANSION OF THE VARIOUS FORMS OF SILICA

A second and very important type of diatomaceous bricks is the pressed brick. This is made according to Krieger (*12*) by moistening a mixture of powdered and granulated diatomaceous earth, shaping in a brick press, drying, and firing in a brick kiln. The temperature of firing should be at least as high as the maximum temperature to which the bricks will be subjected during use. Otherwise, they will be subjected to additional shrinkage during use, with consequent development of cracks in the wall made of those bricks.

Coss (*13*) has recently invented the Super-Brick that contains largely tridymite, a form of silica that shows no very sudden expansion or contraction in volume with temperature change. These bricks may be used at temperatures as high as 1400°C. and, presumably, are fired during manufacture to about that temperature.



Courtesy The Celite Co.

FIGURE 5.—BRICK SAW OF STARR AND MARSH CUTTING DIATOMACEOUS BRICK DIRECTLY FROM QUARRY RACE

Note the depth to which this quarry has been cut away.

Blocks of diatomaceous earth, like the bricks, are much used as thermal insulators. The blocks are of various dimensions, such as $36 \times 12 \times 2$ inches. Such slabs, being much larger units than bricks, require less labor in application to a surface to be insulated. These slabs or blocks are made by bonding diatomaceous powder with asbestos and lime, in the Belknap process (*14*), or with asbestos and hydrated basic magnesium carbonate, according to the invention of Boeck and Jordan (*15*).

Dewaxing of Lubricating Oil

When an ambitious general manager requested the research laboratory to increase by thirty per cent the rate at which liquids might be filtered through powdered diatomaceous earth and the laboratory responded with a process that increased the rate not thirty but several hundred per cent, entirely new fields of usefulness were opened to the filter-aid. One such is the dewaxing of lubricating oil. Known from the work of Weir and Ryan (*16*), the process became commercially feasible after calcined diatomaceous filter-aid came on the market.

In dewaxing lubricating oils by this process, the oil is diluted with about an equal volume of naphtha, chilled to crystallize the wax, and then filtered with calcined diatomaceous earth, usually the special grade known as Hyflo Super-Cel. There is used, suitably, one-half pound of Super-Cel to one gallon of the diluted oil. The incorporation of the filter-aid into the chilled oil, before filtration, ensures the building of filter cakes that are relatively more permeable than would be the case if the solid in the cakes consisted solely of wax.

The filter cakes contain the Super-Cel and the crystallized wax. They are puddled with warm naphtha and again filtered. The new cakes in the filter consist largely of Super-Cel in condition suitable for reuse. The filtrate is a naphtha solution from which wax is recovered by evaporation.

This process has considerable merit. Wide use of it is anticipated.

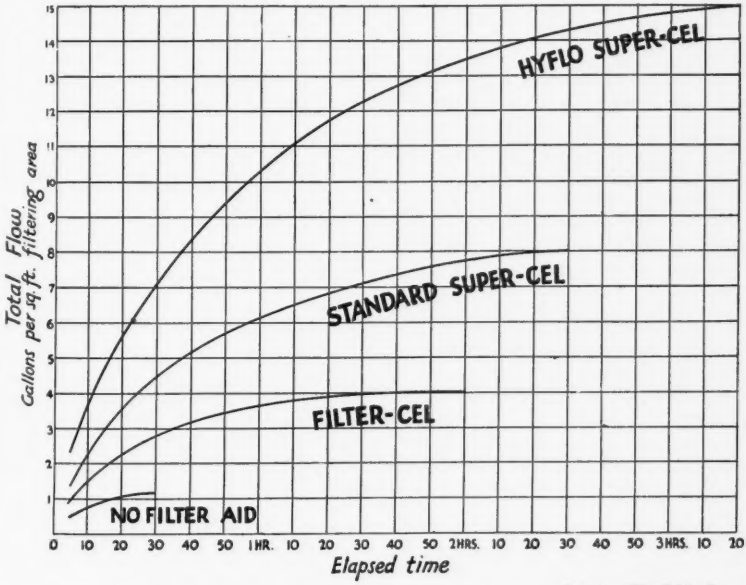
Cane Sugar Refining

The invention of calcined diatomaceous powder has affected cane sugar refining also. This improved filtration powder makes possible the use of less filter-aid and also faster rates of filtration than formerly.

The filtration step is one of the first in the process of refining cane sugar. Raw sugar, either after or without a preliminary washing of the crystals with water in a centrifuge, is dissolved in water at 80°C., to give a solution that contains sixty pounds of sugar to forty of water. This solution is then neutralized with lime. Next there is stirred in pulverized diatomaceous earth, in the proportion of about three to ten pounds for each ton of raw sugar dissolved. The mixture is pumped into a pressure filter, frequently of the Sweetland suspended leaf type.

The leaves of the filter are cloth covered, in the usual manner. As filtration proceeds, there collects on the cloth a relatively porous cake of diatomaceous earth. In this are retained the dirt, cane wax, slime, and bacteria originally present in the raw sugar. After the first minute or two of the filtration cycle, the filtrate is sparklingly clear and highly suitable for treatment to remove color and crystallize the sugar in the later steps of the sugar-refining process.

The effect of adding the diatomaceous filter-aid previous to the filtration is best demonstrated by trying a filtration of a raw sugar solution without


HYFLO SUPER-CEL
STANDARD SUPER-CEL
FILTER-CEL
NO FILTER AID
Total Flow
Gallons per sq. ft. filtering area
Elapsed time
0 10 20 30 40 50 1HR. 10 20 30 40 50 2HRS. 10 20 30 40 50 3HRS. 10 20

Courtesy The Celite Co.

FIGURE 7.—RELATIVE VOLUMES OF FILTRATE OBTAINED WITH A TYPICAL LIQUID AND EQUAL PROPORTIONS OF DIFFERENT FILTER-AIDS OR NO FILTER-AID

the use of any aid. Without the aid there are several distinct stages in the filtration. First, the sugar solution rushes through the filter-cloth at a great rate, but the filtrate is not clear. Then, suddenly the rate slows down as the slime begins to form a relatively impervious cake on the cloth. Finally, the filtration practically stops.

This experience illustrates well the point that the filter cloth is merely a support for the filter cake which is the actual filtration medium. The addition of an adequate proportion of diatomaceous earth, before starting the filtration, ensures the building of a cake through which liquid can

be made to flow for a reasonably long time. With such a cake that is always porous, the rate of filtration, at any stage during the cycle, is practically inversely proportional to the thickness of the cake. This thickness of cake, in turn, is directly proportional to the square root of the time elapsed since the beginning of the cycle. For example, there is filtered almost exactly twice as much liquor in sixty minutes as in fifteen and, likewise, twice as much in four hours as in one hour. This is as it should be, if the only variable during the cycle is the thickness of the filter cake. The permeability of the cake must, therefore, be the same throughout. Graphs illustrating this point, as well as the effect of various factors on the rate of filtration, particularly of sugar solutions, are given in the monograph on this subject (*1*).

The best proportion of filter-aid to solution to be filtered should be determined by experiment. The greater the percentage of slime present, the higher, usually, will be the amount of filter-aid needed. Thus molasses, which contains a high proportion of impurities, requires a very large amount of filter-aid, raw sugar requires less, and a raw sugar that has been "affined" or partially purified by washing with water before being dissolved in water requires still less aid.

The effect of adding filter-aid before filtering a typical liquor is shown in Figure 7.

Sterilization by Filtration with Diatomaceous Earth

An interesting effect of filtration with diatomaceous earth is the removal of bacteria. The importance of the fermentation of raw sugar, for example, is indicated by the estimate of Browne (*17*) that the loss by fermentation of Cuban sugar alone exceeds a million dollars a year.

The removal of bacteria by filtration with diatomaceous earth has been studied by Kopeloff (*18*), Owen (*19*), Greig-Smith (*20*), and Calvert and Knight (*21*). Kopeloff found that filtration of cane juice through diatomaceous earth removed, on the average, 99.72 per cent of the bacteria and 100.00 per cent of the fungi originally present. Owen confirmed this. He carried the work to the point of demonstrating that the filtration merely removed the microörganisms without leaving in the juice any material which inhibits the multiplication of microörganisms subsequently introduced into the filtered liquor. Calvert and Knight filled fermentation tubes with raw sugar solutions that had been treated, in one way or another, and filtered with diatomaceous earth. These did not develop gas on standing. Other tubes, filled with solutions that had been given the same treatments, except for the filtration, underwent fermentation as shown by the gas collected (see Figure 8).

Another example of the use of diatomaceous earth in stopping fermentation is the arrested fermentation process of making near-beer. When the

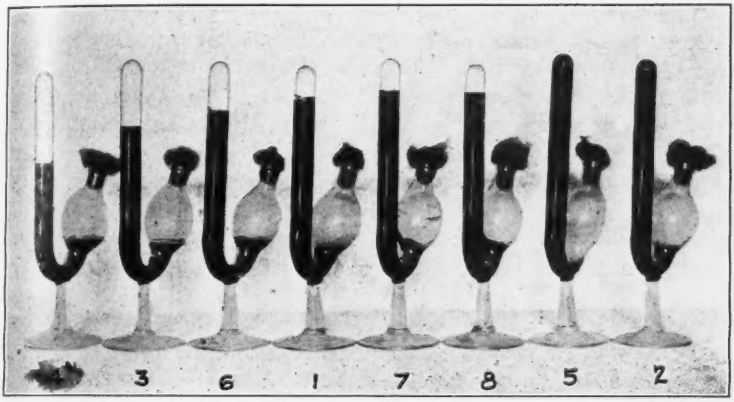


FIGURE 8.—STERILIZATION OF SUGAR SOLUTIONS BY FILTRATION
Gas developed in all tubes except numbers 2 and 5 which had been filtered with diatomaceous earth.

alcohol content of the mash approaches that allowed by the prohibition law, powdered diatomaceous earth is added and the mixture filtered.

Grape juice, likewise, is sometimes filtered with diatomaceous earth in order that pressure may not be developed by fermentation of the juice after being bottled.

In a laboratory filtration of a sample of impure water with diatomaceous earth, the number of bacteria per cc. was reduced from 1200 to 1 (*21*).

Admixture in Portland Cement

General.—The admixture of diatomaceous earth in concrete received a great impetus during the World War, at which time the earth was employed in several concrete ships built for the Emergency Fleet Corporation. Since that time the use in general concrete work has expanded rapidly, in highway construction, buildings, in underground structures, such as the Philadelphia subway, and in hydraulic engineering projects.

The admixture of diatomaceous earth with portland cement has been studied by Edelmann and Wallin (*22*), Duryee (*23*), Lippincott (*24*), Poulsen (*25*), Abrams (*26*), Pearson and Hitchcock (*27*), and, finally, by Conner (*28*). Hutchison, while with the North Carolina State Highway Commission, did a great deal of excellent work, including practical testing of diatomaceous earth in highway materials.

Used originally to correct the tendency of certain cements to change in volume after setting, then to give increased water-tightness and tensile strength, diatomaceous earth is now coming into use chiefly to increase the workability and decrease the tendency to segregation of concrete.

A small amount, usually two to five per cent by weight, of finely powdered diatomaceous earth is incorporated into the cement. The mixture is then employed in concrete in the usual manner.

Increase in Waterproofness.—In the Los Angeles aqueduct, according to Duryee, are several inverted siphons, ten feet in diameter, with heads of sixty to seventy feet of water. These were made with portland cement ground with tufa. Although tufa contains less reactive silica than diatomaceous earth, the siphons made from cement containing that tufa remain dry on the outside.

The increase in water-tightness and the neutralization of the lime are especially important when the cement casting stands in contact with water containing acid, such as formed in sea water or in sewage, by hydrolysis of chlorides or sulfates. The action of acid upon the free lime of cement is hindered by the diatomaceous admix, not alone by the decrease in the porosity with a consequent improvement in degree of water-proofness, but also by actual combination of that lime with the diatomaceous earth to give calcium silicate. This effect is illustrated by tests of Duryee (Table III) with various proportions of the admix.

TABLE III

Effect of Fresh and Sea Water on Cement Mortar[a]

Water	*Admixture*	*Breaking Strength, Lb. per Sq. In.* 7 Days	28 Days	3 Mo.	6 Mo.
Fresh	None	205	310	332	385
Fresh	Diatomaceous Earth	270	476	418	531
Fresh	Diatomaceous Earth	201	334	414	460
Fresh	Diatomaceous Earth	148	488	465	523
Fresh	Diatomaceous Earth	177	313	441	405
Sea	None	...	...	...	316
Sea	Diatomaceous Earth	...	...	478	808
Sea	Diatomaceous Earth	...	...	...	808
Sea	Diatomaceous Earth	...	...	...	498

[a](1 to 3 of sand, by weight.)

Strength.—The admixture of diatomaceous earth into concrete increases also the strength of the concrete after setting, to an extent which will be evident from the summary of data in Table IV as well as that of Table III. In interpreting such data it is important to bear in mind, as M. R. J. Wig* has pointed out, that dryness of concrete at the time of pouring affects the strength after setting. The principal reason why diatomaceous admix increases the final strength of the concrete is that drier consistencies may be employed more satisfactorily when diatomaceous earth is present than otherwise.

* Private communication.

TABLE IV

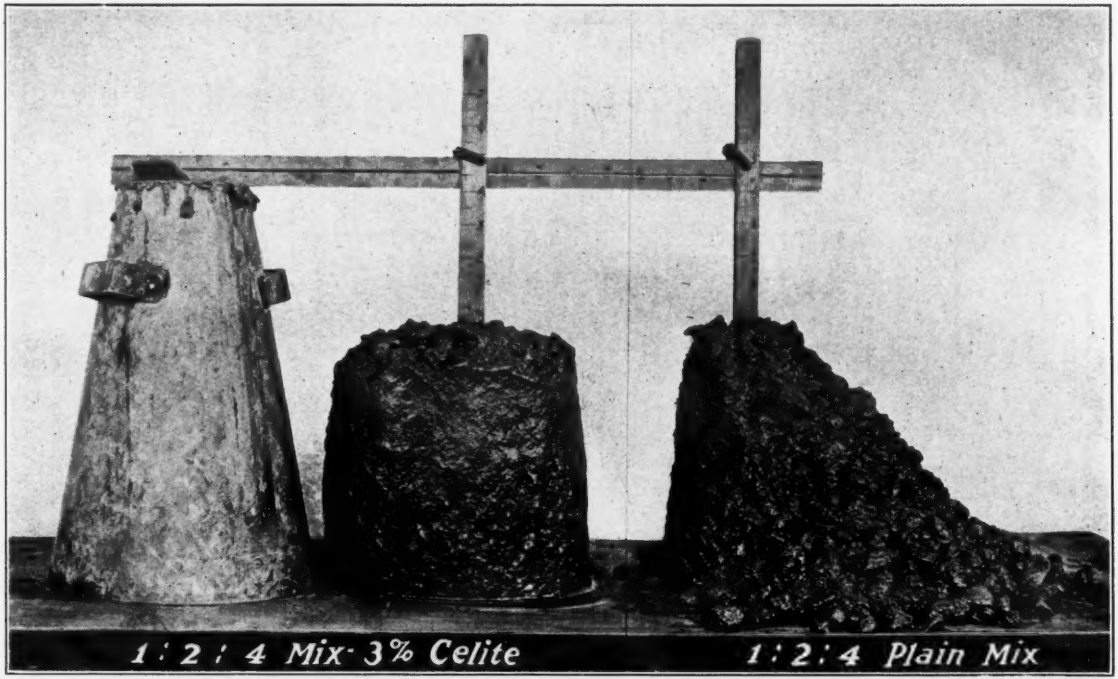
Effect of Admixture on Strength of Concrete

Test by	*Date of Report*	*Mix*	*Per Cent Celite by Weight of Cement*	*Slump*	*Age When Broken*	*Average Compressive Strength Lb./ Sq. In.*	*Relative Compressive Strength Plain Concrete = 100*	*Variation between Minimum and Maximum Strength*
Robt. W. Hunt Co.	9–22–25	1:2:4	0	4½″	28 days	2349	100	843
Chicago, Ill.	9–22–25	1:2:4	4	5⅝″	28 days	2948	125.5	364
Pearson and Hitchcock at								
U. S. Bureau of Stand-	1923	1:3:6	0	7.2″	28 days	1044	100	Not
ards, Washington, D. C.	1923	1:3:6	3.3	7.4″	28 days	1129	108.1	given
No. Carolina State	12–17–25	1:3:6	0	Not	1 year	Not	100	Not
Highway Dept.	12–17–25	1:3:6	4½	given	1 year	given	118	given
Highway Dept.	12–17–25	1:2:4	0	Not	1 year	Not	100	Not
Highway Dept.	12–17–25	1:2:4	3	given	1 year	given	114	given
Pittsburgh Testing Lab.,	1–25–26	1:2:3½	0	3″	14 days	1516	100	Not
Pittsburgh, Pa.	1–25–26	1:2:3½	3	3″	14 days	1555	102.6	given
Northwest Testing Lab.,	12–18–25	1:2:4	0	7¾″	28 days	3309	100	486
Seattle, Wash.	12–18–25	1:2:4	3	7¼″	28 days	3572	107.9	322
Pierce Testing Lab.,	10–9–25	1:2⅜:2⅜	0	7¾″	28 days	2198	100	75
Denver, Colo.	9–24–25	1:2⅜:2⅜	3	4½″	28 days	2558	116.4	45
Pacific Testing Lab.,	2–6–26	1:3:5	0	6½″	28 days	1010	100	8
Seattle, Wash.	2–25–26	1:3:5	3	5½″	28 days	1190	117.8	8
City of Long Beach,	4–22–26	1:2:4	0	2½″	21 days	1971	100	326
California	4–22–26	1:2:4	3	2¾″	21 days	1951	99	75
State of Ohio,	10–16–25	1:2:3	0	1½″	28 days	4220	100	Not
Columbus, O.	10–16–25	1:2:3	3	1½″	28 days	5600	132.7	given
Abbot A. Hanks, Inc.,	3–4–26	1:3 Mortar	0	Not	28 days	4313	100	Not
San Francisco, Calif.	3–4–26	1:3 Mortar	3	given	28 days	5271	122	given

Workability.—The addition of diatomaceous earth to concrete decreases the tendency to segregation of the particles in the wet mixture and makes the mixture more workable. This is illustrated in Figures 9 and 10.

Thermal Insulation

The importance of insulation to prevent loss of heat is obvious. Less apparent but equally true is the fact that diatomaceous earth is the one effective and convenient insulator for use at very high temperatures. Such other well-known thermal insulators as asbestos or 85% magnesia shrink at temperatures below red heat and thus develop cracks in a furnace wall constructed of such insulators. Diatomaceous bricks, on the other hand, may be used at any temperature as high as that to which the bricks were fired during manufacture. Thus Super-Brick is satisfactory up to temperatures of approximately 1400°C.



Courtesy The Celite Co.

FIGURE 9.—EFFECT OF DIATOMACEOUS EARTH ON THE WORKABILITY OF CONCRETE

The two mixtures have the same slump, yet the batch containing Celite has greater cohesiveness and plasticity.

That diatomaceous compositions should be effective as thermal insulators is to be expected.

Convection is decreased or practically eliminated by diatomaceous earth. The pores in diatomaceous compositions are mostly microscopic and non-communicating; no appreciable circulation of air is possible.

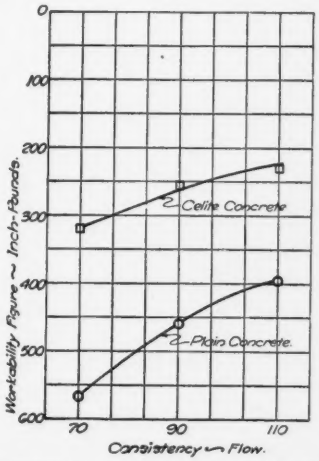
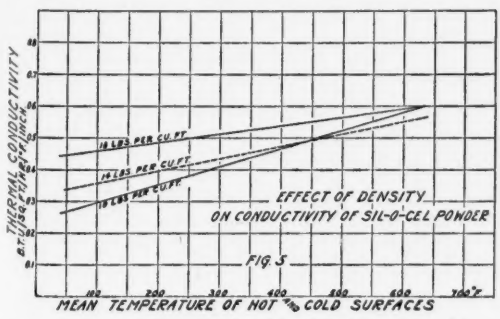


FIGURE 10.—WORKABILITY OF PLAIN AND DIATOMACEOUS CONCRETES

The vertical scale shows approximately the effect (here expressed in inch-pounds) required to move or place the concrete.

Radiation also is greatly reduced by the myriad reflecting surfaces that bound the pores in particles of diatomaceous earth. That transfer of heat by radiation is not entirely eliminated, however, is shown by the slope of the graphs in Figure 11. The powder of lowest density shows greater relative increase in heat transfer with rising temperature than powders packed more densely and, therefore, containing smaller interstices between the particles. It will be interesting to recall that radiation varies with the fourth power of the absolute temperature and to note from the figure that the powder of lowest density becomes the best transmitter of heat at temperatures above 630°C. For the same reason, a vacuum or an air space transmits more heat at furnace wall temperatures, at which transfer is largely by radiation, than an equal thickness of firebrick (*29*).

Conduction of heat, however, depends to a large extent upon the amount of matter or number of molecules available for carrying the heat. For this reason the very light diatomaceous earth, with its numerous voids, is an especially poor conductor. One may hold in the hand a diatomaceous brick against the other side of which a blast lamp flame is directed.


THERMAL CONDUCTIVITY
B.T.U./SQ. FT./HR./°F./INCH
10 LBS PER CU FT
14 LBS PER CU FT
18 LBS PER CU FT
EFFECT OF DENSITY
ON CONDUCTIVITY OF SIL-O-CEL POWDER
FIG. 5
MEAN TEMPERATURE OF HOT & COLD SURFACES

Courtesy Industrial and Engineering Chemistry

FIGURE 11.—RELATION OF TEMPERATURE AND DENSITY TO THERMAL CONDUCTANCE OF DIATOMACEOUS POWDER

Conduction of heat follows much the same formula as conduction of electricity. In each case the energy flow is from a region of high potential to one of lower, as measured by temperature and voltage, respectively. The influence of potential difference, $V_1 - V_2$ or $t_1 - t_2$, specific conductance, k, area of cross-section, A, and length, L, of the conductor on the quantity, Q, of energy transmitted in a given time, T, is as follows:

$$Q = k \frac{A(V_1 - V_2)}{L} T, \text{ for electrical conduction.}$$

$$Q = k \frac{A(t_1 - t_2)}{L} T, \text{ for thermal conduction.}$$

In the insulation of a furnace, for example, it is not possible to vary at will the value of $t_1 - t_2$, for this is the difference between the temperatures of the inside and outside of the wall of the furnace. Neither is it feasible to reduce, beyond certain limits, the area, A, of wall through which the heat flows. We may vary the thickness, L, of the layer of insulation, but to increase this thickness increases the cost also.

Perhaps the most readily varied factor in the above equation is k, the specific conductance. By choosing a good insulator, we get a low value for k and a correspondingly small amount, Q, of heat transferred. The extent to which k varies for three types of bricks is shown in the following table, in which the specific conductance is expressed as the number of British thermal units transferred in one second through one inch of thickness per square foot of area of conductor, measured at a right angle to the direction of heat flow, for a temperature gradient of 1°F. per inch of thickness of the conductor.

TABLE V

Specific Thermal Conductance of Bricks

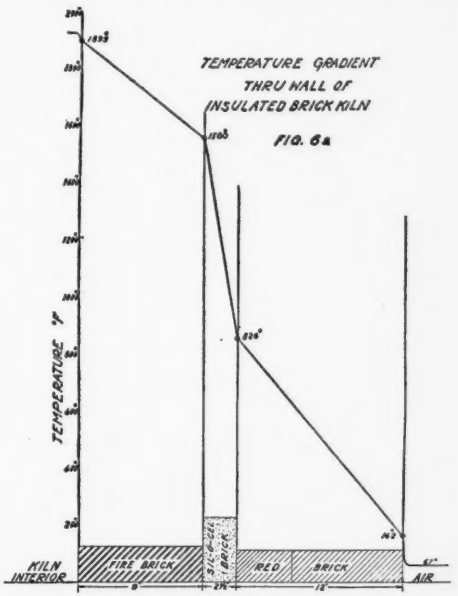
Kind of Brick	*Specific Thermal Conductance at Mean Temperature Indicated*
Firebrick	9.5 at 1737°C.
Diatomaceous Brick (Natural)	1.1 at 1203°C.
Red Brick	6.0 at 494°C.

The effect of the differences in thermal conductances of the several bricks on the calculated temperature gradient of the wall of a brick kiln is shown in Figure 12. The large drop in temperature through the relatively thin layer of insulating brick is especially interesting. It is also important; a large drop in temperature in an insulating layer of a furnace wall gives, of necessity, a lower temperature on the cooler or outer side of the wall and, consequently, a smaller loss of heat to the atmosphere. In this manner, diatomaceous earth saves thousands of tons of coal or oil yearly for many users. One installation on annealing furnaces saves 20 gallons of fuel oil per ton of iron annealed.

Breaking Oil Emulsions

The problem of separating intimate emulsions of oil and water has many solutions, none of which is as convenient or satisfactory in all cases as might be desired. One recently tried process is passage of the emulsion through a layer of calcined diatomaceous filtration powder in a pressure filter (*30*), (*31*), (*32*). Certain emulsions that do not separate on long standing before filtration part readily into an oil and a water layer after the filtration.

Two theories have been advanced to explain this effect. First, the diatomaceous earth may remove dirt, asphalt, or other substance whose presence stabilizes the emulsion. Second, filtration through the multiplicity of capillary passages may so distort the emulsified droplets of the dispersed phase as to make contact with other droplets and thus cause coalescence into drops of such size as to settle readily in the filtered mixture.



Courtesy Industrial and Engineering Chemistry

FIGURE 12.—CALCULATED TEMPERATURE GRADIENT THROUGH SIDE-WALL OF INSULATED BRICK KILN

Support for Catalysts

A common procedure is the precipitation of catalyst within the pores of diatomaceous earth, to increase the extent of surface and the bulk of an otherwise expensive catalyst.

Catalysts for use in a stream of gas may be thus distended or supported on diatomaceous granules of such size as to allow of ready flow of gas around them. For use with liquids, the catalyst is preferably supported on powdered diatomaceous earth.

An example of the latter is a composition suitable for use in the hydrogenation of cottonseed oil. Powdered diatomaceous earth is impregnated with a solution of nickel sulfate into which is then stirred a solution of an alkali, to precipitate nickel hydroxide. After being washed, dried, and reduced, the product should contain about thirty per cent nickel by weight (*33*). Because of the low density of the earth as compared to

nickel, the composition has a volume probably more than one hundred times that of the nickel metal alone in compact form.

Polishing Compositions

Polishing compositions frequently consist of a paste of diatomaceous powder, as a mild abrasive, water, soap, and an oil. These compositions are particularly useful in polishing silver ware, lacquered metal ware, such as automobile bodies, and other objects with which a harsh abrasive would be objectionable.

Fertile Field for Research

Diatomaceous earth combines uniqueness of properties with newness of opportunities for research. Although there have been able students of diatomaceous earth, discoveries of fundamental importance are yet possible. Nearly all of the present large uses are developments of the last twenty years. Just last year there was developed a product that should increase consumption of the earth by 10 to 20 per cent. Another large use is reported to have been discovered this year.

Of future inventions, many will result from attempts of the chemist or engineer to use the material in his industry.

With such discoveries in prospect, diatomaceous earth will become better understood and even more widely used than at present.

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Copper Oxide "Sandwich" Converts Light to Electricity. Running motors with electricity from sunlight is one of the possibilities forecast by the invention of a new type of cell that converts light directly into useful quantities of current. It is the invention of Dr. B. Lange, of the Kaiser Wilhelm Institute for Silicate Investigation. Previously this has not been possible. The new cell, the essential part of which is a "sandwich" of copper oxide between two layers of metallic copper, may also prove a revolutionary improvement in talking movies and television and in many phases of scientific work.

Ordinary photoelectric cells, consisting of a layer of a metal such as potassium inside a glass bulb containing either a vacuum or a small amount of inert gas, can only be operated with an auxiliary source of electric current. When light falls on the potassium layer, electrons are given off. When connected to a battery, or other source of current, the electrons are carried to another metal plate or wire which forms the other electrode. Thus, the flow of the current is regulated by the amount of light falling on the potassium layer.

In Dr. Lange's cell, the light falls on one of the thin copper layers and the electrons are driven off. They pass through the copper oxide layer, which is exceedingly thin, only a few layers of molecules in depth. When they reach the other layer of copper an electric current results. Because of the short distance through which the electrons have to travel, the cell operates without the slightest appreciable lag. The current given off is powerful enough that when a rapidly flickering light shines on the cell, the current can be fed into a loud speaker and a note vibrating at the same rate as the light can be heard.

Other advantages of the copper cell are that it does not show fatigue as does the ordinary type, it can be operated indefinitely without loss of efficiency and it is much more sensitive to the infra-red waves, too long to be visible.

In round numbers, Dr. Lange estimates, his new cell is ten times as efficient as the older types. But by the proper adjustment of the middle layer, and the use, perhaps, of other materials than copper oxide, he foresees the possibility of increasing the efficiency still further and converting light directly into large quantities of electricity. Even as constructed at present, the cell should prove a radical improvement in talking movies and television. It will also, suggests Dr. Lange, be useful as a photometer, to measure light intensity, because the current given off is directly proportional to the light falling on it, over a long range of brightness.—*Science Service*

ACID AND ALKALI IN HEALTH AND DISEASE

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Living beings can adapt themselves to a great variety of external conditions. In so doing, surprisingly small changes take place within the body. Thus, the temperature is nearly constant, the rate of the pulse varies but little, while certain properties of the blood remain practically unchanged, for example, the hydrogen-ion concentration and the osmotic pressure. The full significance of this constancy is not known; but enough has been discovered in recent years to justify a consideration of the mechanism whereby the body maintains constancy of hydrogen-ion concentration, and a consideration of the changes which occur in disease.

The normal adult eliminates from the body large quantities of acid substances (Table I). Moreover, the rate of elimination and of production of acids varies greatly from time to time. Nevertheless, the hydrogen-ion concentration of the plasma,[1] and presumably of the cells, is maintained nearly constant at a pH of about 7.35. It must be emphasized that this constancy is brought about by certain physiological mechanisms which depend upon a series of physico-chemical reactions. The view which would place the entire emphasis upon a known physico-chemical system is too narrow. For the sake of clarity we shall first consider the physico-chemical aspect of the problem.

Mechanism for Maintaining Normal Hydrogen-Ion Concentration in Blood and Tissues

The Buffer-Effect.—As is obvious from Table I, carbon dioxide is the chief acid product of elimination. It should therefore be considered first in any discussion of the acid-base equilibrium of the body. Since the tissues contain appreciable quantities of the bicarbonate ion and of carbon dioxide, and since we are to think in terms of a physico-chemical system, it is apparent that other "stronger" acids than carbonic which may exist in the living organism can be considered in terms of their equivalent in carbon dioxide

TABLE I

Acids Eliminated per Day, Normal Adult—Weighing 64 Kg.

Element	*Wt.-gm.*	*Acid-ion*	*Moles*	*Cc. N/10*	*Elim. by*
C	207	HCO_3	17.25	172,500	Lung
P	0.73	H_2PO_4	0.0235	235	Kidney
S	0.46	SO_4	0.0287	287	Kidney
Cl	3.77	Cl	0.1076	1076	Kidney
..	...	Organic	0.030	300	Kidney
			0.1898	1898	Kidney

[1] *Plasma:* The fluid of the blood in which are suspended the blood corpuscles, both red and white.

or bicarbonate. Table II shows that the anions of the plasma include anions of "weak" acids—bicarbonate, phosphate, and protein; and anions of

Table II

Anions of Plasma

	Adult	*Child*
Cl	103.5	100
HCO_3^-	25.8	24
Protein	11.4	10
$HPO_4^=$	2.3	4
Rest	12.1	12
Total	155.1	150

In terms of cc. of $N/10$.

"strong" acids—chiefly chlorides. As is well known, such a system exhibits a buffering effect, *i. e.*, the addition of acid or alkali results in only a slight change in pH. Buffering constitutes the "first line of defence" against changes in reaction of the tissues. This effect has been studied by subjecting plasma or defibrinated blood[2] to various tensions of CO_2, and measuring the changes in the bicarbonate content and in the pH.

The Effect of Oxygen.—When oxygen combines with the protein of the red blood corpuscles (*i. e.*, hemoglobin[3]), this protein becomes a stronger acid. The changes which result from this reaction in the red corpuscles may be indicated as follows:

$$Hb{\cdot}H + KCl + O_2 \qquad HbO_2{\cdot}K + HCl$$

Since the protein molecules and the potassium ions are unable to pass out of the red cells, whereas the hydrogen and the chloride ions are able to do so, the effect of oxygenating hemoglobin is to introduce a strong acid into the plasma; this acid displaces a definite amount of CO_2. These reactions take place in the lungs. Since the liberated CO_2 can escape, the pH of the blood tends to remain constant. Conversely, in the tissues, when the blood parts with oxygen, the hemoglobin becomes reduced, thus forming a weaker acid; chloride and hydrogen ions enter the red cells, and as the plasma becomes more alkaline it is able to take up CO_2 from the tissues with little or no change in reaction (see Figure 1). Actual analysis of venous and arterial blood taken directly from the body and of defibrinated blood afford objective proof of the truth of these statements. They also give a quantitative idea of the relative importance of the various buf-

[2] *Defibrinated Blood:* The clotting of blood is due to the formation of a gelatinous mesh of protein material known as fibrin. If blood is shaken with beads or stirred during the process of clotting, the fibrin separates as a small compact elastic mass, leaving the greater bulk of blood still fluid. Such blood is called "defibrinated."

[3] *Hemoglobin:* The coloring matter found in the red blood corpuscles. It unites with oxygen to form "oxyhemoglobin," from which oxygen is again readily given up. These changes may be written: $Hb + O_2 \rightleftharpoons HbO_2$.

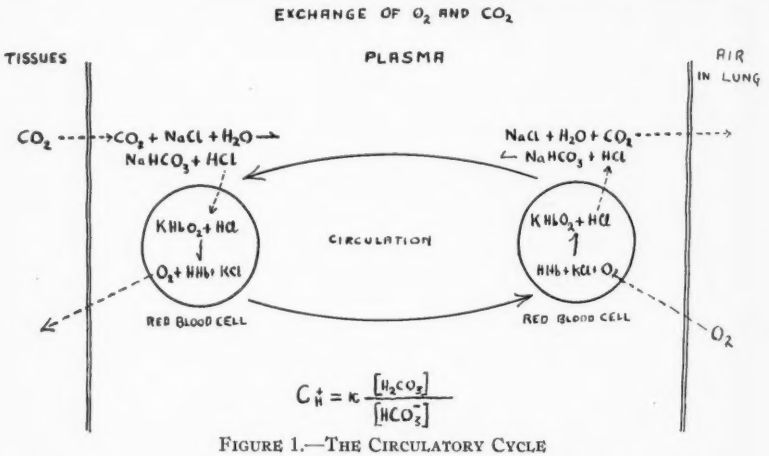

FIGURE 1.—THE CIRCULATORY CYCLE

fers and of the change from reduced to oxidized hemoglobin in the transportation of CO_2.

Attention is called to the chart copied from D. D. Van Slyke (Figure 2). The concentration of hydrogen ions in a buffered solution containing free carbonic acid and bicarbonate is given by the simple equation:

$$C_H = K' \frac{(\text{Free } H_2CO_3)}{(BHCO_3)}$$ K' being a certain constant.

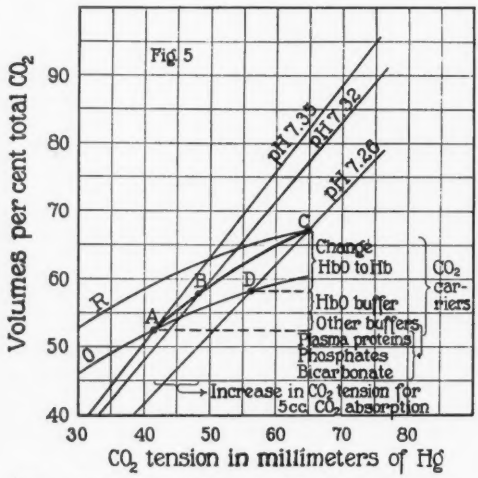

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FIGURE 2.—THE CO_2 CARRIERS OF THE BLOOD

The numerator, representing the concentration of free H_2CO_3, is a linear function of the tension of CO_2 in equilibrium with the system; and the denominator, representing the concentration of CO_2 combined as bicarbonate, is a quantity about twenty times as great as the free CO_2. It can be shown that:

$$C_H = K \frac{CO_2 - \text{tension}}{\text{Vol. per cent total } CO_2}$$

Thus, the lines on the diagram which represent

constant pH will be straight, *e. g.*, those marked pH 7.35, pH 7.32, and pH 7.26.

The line *RC* represents the change in CO_2 capacity of fully reduced blood with varying tensions of CO_2. The line *OAD* represents the changes in CO_2 capacity of the same blood fully oxygenated. The point *C* might be taken to represent the conditions in the tissues: the blood is reduced, in equilibrium with CO_2 at a tension of 65 mm., and at pH 7.26. The point *A* might represent the conditions in the lungs; the blood oxygenated, in equilibrium with CO_2 at a tension of 40 mm., and at pH 7.35. The relative importance of the various carriers of CO_2 can be represented by supposing two successive changes to occur: (1) oxygenation at constant pH 7.26, represented by the line *CD;* buffers play no rôle; the change in CO_2 capacity is due entirely to the increased acidity of the oxyhemoglobin; (2) fully oxygenated blood loses CO_2 and changes in pH from 7.26 to 7.35; represented by the curved line *DA*. The change in CO_2 capacity is wholly due to the buffers. Data not shown here indicate the relative importance of the various buffers.

So much for the known physico-chemical system employed by the organism to preserve its reaction. The effective operation of this system obviously depends upon a series of biological responses; in particular, upon the maintenance of adequate circulation of the blood, upon adequate exchange of gases in the lungs, or pulmonary ventilation,[4] and upon the elimination of non-volatile acids by the kidneys.

Pulmonary Ventilation.—The rate and depth of breathing is controlled by a nervous center in the medulla oblongata.[5] This respiratory center is most sensitive to changes in the reaction of the blood passing through it. Slight increase in the acidity of the blood causes relatively great increase in the pulmonary ventilation, as can be demonstrated by any one who breathes air rich in CO_2. The relationship between the amount of pulmonary exchange and the CO_2 content of air breathed is shown in Figure 3. The obvious effect of increased pulmonary ventilation is loss of CO_2, with restoration of the normal reaction of the blood. The stimulating effect of CO_2 upon respiration is utilized to remove volatile anesthetics from the body; and to remove carbon monoxide from the blood in case of gas-poisoning. In certain pathological conditions, the respiratory center may be less sensitive, leading to an accumulation of CO_2; if the kidneys cannot remove acids rapidly enough, there exists the possibility of "acidosis of

[4] *Pulmonary Ventilation:* The term applied to the quantity of air breathed into the lungs.

[5] *The Medulla Oblongata:* The portion of the brain situated at the upper end of the spinal cord. In the medulla oblongata are found two groups of nerve cells, called "centers" which control, respectively, the heart beat and the depth and frequency of respiration.

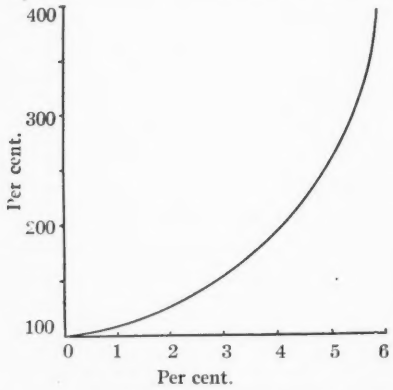


FIGURE 3.—INCREASE OF PULMONARY VENTILATION DUE TO BREATHING MIXTURES OF CARBON DIOXIDE AND AIR

Abscissas, percentage of CO_2. Ordinates, volume of air breathed, in terms of per cent of the normal.

the CO_2 type." On the other hand, excessive irritability of the respiratory center may result from tumors of the brain, from inflammation, or possibly from an inborn defect. In such cases, too much CO_2 is withdrawn from the blood, leaving a relative excess of bicarbonate; this results in a change toward alkaline reaction, or alkalosis. Such an "alkalosis" is even more serious than "acidosis," and is characterized by an irritability of the nervous system, which may result in convulsions.

Rôle of the Kidney.—The kidney helps to preserve a constant reaction in the tissues in two ways. First by excreting an acid urine while the blood is distinctly alkaline. This is sometimes expressed by saying that the kidney eliminates acid phosphates, and returns alkali to the blood, thus:

$$\underset{\text{In blood entering kidney}}{Na_2HPO_4} + CO_2 + H_2O \longrightarrow \underset{\text{In urine returned to blood}}{NaH_2PO_4} + NaHCO_3$$

A certain amount of fixed base (*e. g.*, Na, K, Ca, Mg) thus leaves the body. Secondly, the kidney possesses a mechanism for the formation of ammonia from urea, a neutral substance; part of the loss of fixed base is thus prevented. A high "ammonia coefficient" is observed in those cases in which acetoacetic acid or betahydroxybutyric acid are formed; for example, in starvation, in diabetic coma,[6] or in persons living upon diets high in fat and low in carbohydrate, thus:

$$\underset{\text{In blood entering kidney}}{CO_2 + 3H_2O + CO(NH_2)_2 + 2Na\cdot\bar{A}c} \longrightarrow \underset{\text{Returned to blood}}{2NaHCO_3} + \underset{\text{Excreted in urine}}{2NH_4.\bar{A}c}$$

Both these mechanisms appear to depend upon the intrinsic powers of the kidney itself and upon the pH of the blood, rather than upon nervous influences. They both fail in certain forms of kidney disease and when the circulation of the kidney is interfered with, as in heart failure.

[6] *Diabetic Coma:* The state of unconsciousness which occurs in the acidosis of diabetes; and which often leads to death.

Acidosis

Acidosis may be defined as a condition in which the alkalies of the tissues have been reduced either through excessive loss of base (*e. g.*, with diarrheal stools) or through excessive retention of acids. If the pH of the plasma falls appreciably, we speak of uncompensated acidosis. Usually, however, the reaction of the plasma is preserved, by the operation of the mechanisms described above. Since the concentration of hydrogen ions is related to the carbonic acid and to the bicarbonate in the following way:

$$C_H = \frac{K'(H_2CO_3)}{(BHCO_3)} = \frac{KT_{(CO_2)}}{(HCO_3)},$$

it is obvious that the tension of CO_2, (T_{CO_2}), must rise and fall in a direct relationship with ($BHCO_3$).

Tests for acidosis involve the analytic determination of the variables: pH, CO_2-tension, or bicarbonate content. In general it may be said that any two suffice to describe the state of the blood and therefore of the tissues which are presumably in equilibrium with the blood.

The colorimetric determination of the pH of the blood is accurate enough for clinical purposes, but probably not trustworthy enough for general use. The tension of carbon dioxide in the alveoli[7] of the lung is usually the same as that in the arterial blood, and can be determined with sufficient accuracy by a colorimetric method. The carbon dioxide content of the plasma can be determined easily and with great precision; its determination has long been in general use. If the case in question is known to be one of acidosis, the carbon dioxide content of the plasma is often taken as an indication of the degree of acidosis. On the other hand, low values of the carbon dioxide content *per se* may not mean acidosis. For example, in the type of alkalosis due to too rapid loss of CO_2 by hyperventilation,[8] there may be a

TABLE III

Clinical Signs in Acidosis and in Alkalosis

		Acidosis	*Normal*	*Alkalosis*
Lungs	Respiration	"Air-hunger"	..	Depressed
	CO_2—tension	10–20 mm.	40 mm.	50 mm.
Urine	After $NaHCO_3$ test with cresol-purple	Acid	Alkaline	Alkaline
	Ketosis	±	0	±
Plasma	Vol. % CO_2	20–30	50	70–100
	pH	7.0–	7.35	7.69

[7] *The Alveoli:* The sacs of the lung into which air passes directly from the bronchioles, finest divisions of the bronchi, or air tubes. In the walls of the alveoli are found abundant fine blood vessels. This arrangement permits rapid exchange of oxygen and carbon dioxide between the blood and the respired air.

[8] *Hyperventilation:* A term applied to breathing which is much more deep and rapid than usual. It may be perfectly normal; as when after violent exercise one is "out of breath."

compensating fall in the bicarbonate of the plasma. In such cases, the urine is alkaline. The variations known to occur in health and in disease in pH, CO_2 tension, and alkali reserve are given in Table III (page 2855).

The most important clinical sign of acidosis is a deep, pauseless type of respiration known as "air hunger." In acidosis, the CO_2 in the lungs is more dilute than normal. Increased pulmonary ventilation is therefore necessary in order to remove CO_2 from the blood at a normal rate.

One of the most important varieties of acidosis is that due to the acetone bodies, acetoacetic acid and betahydroxybutyric acid. Whenever increased amounts of these acids are found in the body, "ketosis" is said to exist. The former acid arises from the incomplete oxidation of fatty acids; the latter is a reduction product of the former. Very often, *e. g.*, during fever or starvation, these acids may be present, though in amounts too small to reduce the alkali reserves of the tissues; a true acidosis then does not result. The best test for the presence of acetoacetic acid is that performed by adding 10% ferric chloride to the urine; a deep, red-brown color is produced. Preliminary boiling of the urine decomposes the acid into acetone and CO_2; this serves to distinguish false reactions due in particular to salicylates, salol, or acetylsalicylic acid (aspirin).

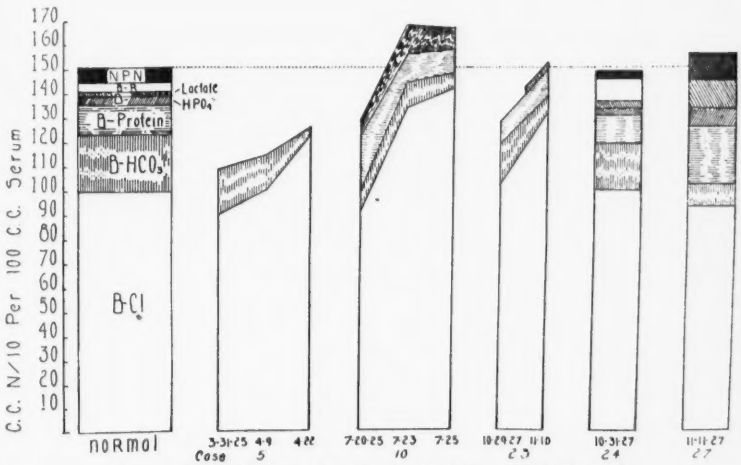
Ketosis occurs whenever fats are incompletely oxidized; since the complete oxidation of fat to CO_2 and H_2 requires the simultaneous oxidation of a definite amount of glucose, ketosis may occur either (1) when there is a deficiency of glucose itself, as, for example, in starvation, or in cases where diets very low in available carbohydrate are fed; or (2) when the glucose-burning power of the body is lost, as, for example, in diabetes mellitus. In the treatment of this form of acidosis too much emphasis was formerly placed upon the use of sodium bicarbonate; at the present time, it may be said that mild forms of ketosis require no special treatment; in severe forms the therapy should be aimed at the underlying cause, rather than at the final condition. Therefore, in diabetic coma, the proper functioning of the kidney must be aided by the administration of fluids; and the failure of the body to oxidize glucose must be met by the injection of proper doses of insulin. Under such circumstances, one can usually observe the rapid disappearance of acetone bodies; and eventually a change in the reaction of the urine toward alkalinity. This change is due to the liberation of the base with which the acetone acids had been combined. In rare cases, these measures alone do not suffice to bring about a diminution of air hunger; then intravenous injection[9] of sterile isotonic[10] (4%) $NaHCO_3$ slowly given is justified; the very spectacular disappearance of air hunger

[9] *Intravenous Injection:* An injection made into a vein, usually for purposes of treatment. It is the most effective and rapid method of introducing substances into the body and is of the greatest practical importance.

[10] *Sterile Isotonic:* For direct injection into the body, material must be free of

and reappearance of consciousness will indicate that sufficient alkali has been administered. Overdoses of alkali may too easily be given; the dangers of "alkalosis" brought about in this manner will be considered later.

Another type of acidosis is observed in severe disease of the kidneys. Ammonia disappears from the urine and phosphates accumulate in the blood. Here again the treatment must be directed against the underlying condition. In such cases, alkalies are especially dangerous, because the kidneys are less able to get rid of any excess.



After A. F. Hartmann, *Am. J. Dis. Children*, **35**, 557 (1928).

FIGURE 4.—ACIDOSIS IN DIARRHEA OF INFANTS

Harmful effect of injections of salt solution shown by rise in plasma chloride and fall in plasma bicarbonate in cases 5, 10, and 23.

In the severe diarrheas of infancy, one meets occasionally with acidosis due to acetone bodies; for example, in bacillary dysentery.[11] It is possible that carbohydrates are not properly absorbed in such cases; or that a peculiar derangement of fat metabolism exists, as evidenced by the fatty degeneration of the liver. More frequently the acidosis accompanying infantile diarrhea is not due to the accumulation of acetone bodies. The

disease-producing germs; *i. e.*, it must be "sterile." For many purposes also, the osmotic pressure must be the same as that of the tissues—the solutions must be "isotonic." Sodium chloride solution 0.85%, "isotonic" with the body, is known as "Physiological Salt Solution."

[11] *Bacillary Dysentery:* One form of diarrhea frequent among babies in summer, and caused by a special germ found in the intestinal contents.

changes in the anions of the plasma are indicated in Figure 4. In some cases a moderate increase of lactates is observed. This increase of lactates probably arises in the following manner. During muscular construction, large amounts of lactic acid are suddenly formed from a non-acid precursor, probably glycogen or glucose:

$$\underset{\text{(Glucose)}}{C_6H_{12}O_6} \longrightarrow \underset{\text{(Lactic acid)}}{2C_3H_6O_3}$$

During its resting stage, the muscle is able to reconvert $^5/_6$ of the lactic acid to its precursor; but in so doing must oxidize $^1/_6$ of it (or an equivalent quantity of glucose) to CO_2 and H_2O. This reöxidation depends upon an adequate supply of available oxygen, and an adequate circulation of blood and fails in cases such as asphyxia, carbon monoxide poisoning, phosphorus poisoning, anemia, and heart failure. In the case under consideration, infantile diarrhea, such great losses of water occur that the blood volume is diminished, and the rate of circulation and oxidation is seriously affected. By administering fluids or by giving transfusions of blood so as to restore normal conditions in the circulatory system, the excess of lactic acid in the blood can be made to disappear. However, in many cases there is no excess of lactic acid; and in the majority, the excess is far too small to account for the acidosis. The diagram (Figure 5) indicates that the loss of HCO_3 ions is accompanied by an increase of Cl ions. There is good evidence for the belief that two factors account for this: (1) loss of base through the intestinal tract, caused by diarrhea; and (2) retention of chlorides by the kidney. The latter factor deserves special note. If we determine the osmotic pressure of the blood serum by the depression of freezing point, or calculate it from the composition of the serum[12] as determined by analysis, we shall find that even in acidosis and in alkalosis, the osmotic pressure tends to remain constant; this constancy is due in large measure to the action of the kidneys. It appears that the kidney retains chloride in this type of acidosis, with the result that the osmotic pressure is preserved. In the treatment of this type of acidosis, physiological salt solution[13] or Ringer's solution[14] is often injected in order to restore water to the tissues and in particular to the blood. The improvement which results in the circulation suffices to lower the lactic ion to normal. Frequently, however, the addition of more NaCl to the blood is followed by a loss of base in the urine, and thus by an increase of the acidosis (Figure 4). We observe here what appears to be a conflict between two norms: (1) the pH of the blood and (2) the osmotic pressure of the blood; the latter seems to win out in

[12] *Serum:* A clear fluid which separates from the clot after the coagulation of blood.

[13] *Physiological Salt Solution:* See footnote on "Sterile Isotonic."

[14] *Ringer's Solution:* An isotonic solution containing sodium chloride, calcium chloride, and potassium chloride.

the conflict. In such cases it is a better practice to administer fluids in the form of solutions of glucose, of sodium bicarbonate, or of sodium lactate.

Alkalosis

When large amounts of alkali are administered, or when fixed acids are lost, *e. g.*, in vomiting which removes HCl from the stomach, the bicarbonate of the plasma rises and alkalosis is said to exist. When appreciable lowering occurs in the pH of the blood, uncompensated alkalosis is said to exist.

The symptoms of alkalosis include depression of the rate and of the depth of respiration, and increased nervous irritability. The respiration may be so much depressed that cyanosis[15] results. The nervous irritability assumes a peculiar form. The tone of the muscles is more or less increased; the muscles of the hands and feet may develop a special form of spasm and convulsions may occur. Fluid is retained, so that occasionally the hands and feet may be swollen. The nervous symptoms form a clinical picture known as tetany.[16] In another form of tetany the same symptoms are accompanied by a lowering of the serum calcium from the normal of 10 mg. per 100 cc. to 7 mg. or less. It is thought that in the tetany of alkalosis, the ionized calcium of the plasma is lowered although the total amount may be about normal. Tetany requires active symptomatic treatment by means of sedatives. Magnesium sulfate (subcutaneous injections of 0.2 g. per kg. of body weight in 10% solution) is almost a specific in bringing temporary symptomatic relief.

The form of alkalosis which results from the loss of HCl from the body after vomiting is of special interest. This is likely to occur whenever obstruction develops at the pyloric end[17] of the stomach. In such cases, the blood may lose much of its chloride ion; the equivalent sodium ion is, however, not lost, but is retained as bicarbonate; so that the osmotic pressure of the plasma is unaltered. Nevertheless, in such cases a most profound upset of the acid-base equilibrium may be present. Here again we see the dominance of the osmotic-pressure norm over the hydrogen-ion norm. In such cases, the kidneys may not excrete alkali until the patient receives injections of sodium chloride solution. This often affords striking symptomatic relief; but, as is always the rule, permanent recovery can be brought about only by relieving the underlying condition.

[15] *Cyanosis:* Blueness of the body, especially seen in the lips and fingers, due to the presence of excess reduced hemoglobin in the circulating blood.

[16] *Tetany:* A disease characterized by continued spasm of the muscles of the extremities. One form occurs in rachitic babies.

[17] *Pyloric End:* The passage way from the stomach into the intestine, known as the pylorus, is surrounded by thick muscles. In some young babies, these muscles may be over-developed, thus preventing the normal emptying of the stomach, and causing vomiting.

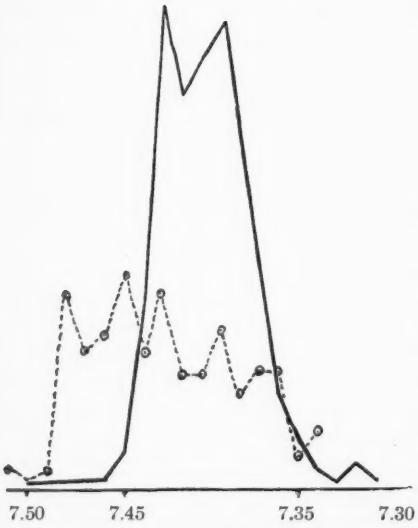


FIGURE 5.—REACTION OF THE BLOOD OF EPILEPTICS

Abscissas denote pH of the blood; ordinates, the relative number of cases with a given pH. The solid line refers to normal persons; the dotted line refers to epileptics while subject to convulsions.

Therapeutic Uses of Acidosis

As we have just remarked, persons with epilepsy may develop convulsions from a degree of alkalosis not affecting normal individuals. The reaction of the blood of epileptics shows interesting departures from the normal. Inspection of Figure 5 shows two things. Normally, the pH of the blood varies within a very

An interesting type of alkalosis results from too rapid loss of CO_2 from the blood following over-ventilation of the lungs. This results in a compensatory lowering of the bicarbonate of the plasma, and absence of ammonia in the urine. Tetany may result. Voluntarily forced deep breathing readily brings about alkalosis. In persons with a predisposition to nervous instability, *e. g.*, epileptics, convulsions may be induced by this voluntary hyperventilation of the lungs. Other diseases of the nervous system, such as hysteria, lethargic *encephalitis* ("sleeping sickness"), and brain tumor may cause an increased activity of the respiratory center, resulting in hyperventilation, alkalosis, and tetany.

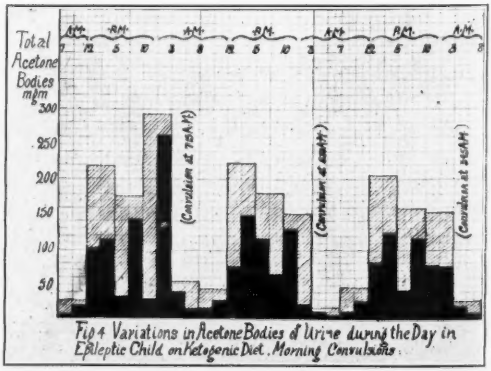
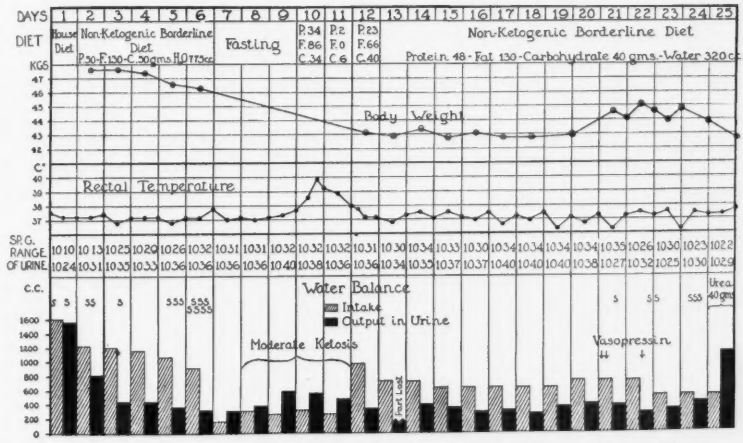


Fig 4 Variations in Acetone Bodies of Urine during the Day in Epileptic Child on Ketogenic Diet. Morning Convulsions.

After I. McQuarrie and H. Keith, *Am. J. Dis. Children*, **34**, 1013 (1927).

FIGURE 6.—CONTROL OF EPILEPTIC CONVULSIONS BY KETOGENIC DIET

narrow range. In epileptics, it is seen that the average pH of the blood rises and that there is a much greater range of variation in the values obtained. This would seem to indicate some disturbance in the maintenance of the acid-base balance. Some years ago, and quite independently of the investigations illustrated i Figure 5, the high fat or ketogenic diet[18] was introduced as a treatment for epilepsy. This diet has proved to be a distinct therapeutic advance (Figure 6). So long as ketosis is kept up, a considerable number of epileptics do not have convulsions. The beneficial effect may be due to one of three things: (1) anesthetic



After McQuarrie, *Am. J. Dis. Children*, **38**, 451 (1929).

FIGURE 7.—CONTROL OF EPILEPTIC CONVULSIONS BY DEHYDRATION

Convulsive seizures (*S*) occurred when patient received large quantities of water (days 1–6) and when he received injections of vasopressin, a constituent of the pituitary gland which causes contraction of the small blood vessels and increase of blood pressure, which caused retention of water (days 21–24) but was free of convulsions after having been dehydrated by means of low intake of water and ketogenic diet.

effect of the acetone bodies; (2) acidosis; or (3) some effect associated with these. The first possibility seems untenable. If has been difficult to assess the value of acidosis *per se*, because it has not been found easy to maintain for long periods of time any type of acidosis not associated with the acetone bodies. One possible consequence of acidosis, important for the control of epileptic convulsions, is dehydration (Figure 7). It has been found possible in practically all cases of epilepsy to stop the convulsions by restricting fluids in the diet, and conversely to bring on convulsions by

[18] *Ketogenic Diet:* A diet of such composition that it does not contain enough available carbohydrate to cause complete oxidation of the fat.

increasing the fluid intake, or by the administration of pituitary extract.[19] The latter causes retention of fluids in the tissues. It must be pointed out that in this work we are dealing with symptomatic factors only, not with the true specific cause of epilepsy. But we may feel assured that the knowledge gained from these studies on acid-base balance and water metabolism is a distinct advance in the search for the more fundamental causes of this malady.

Conclusion

In this paper, the mechanism has been described whereby the body attempts to preserve its normal reaction. The effects of abnormal reaction, acidosis on the one hand and alkalosis on the other, have been described. Although in these conditions an appreciable alteration takes place in the acid-base balance, there is little or no change in the osmotic pressure. The mechanism which preserves constancy of osmotic pressure may in such cases do harm to the body. It has been pointed out that there presides over these physico-chemical mechanisms a fundamental biological activity which utilizes such mechanisms so as to make the body react as a whole.

* * * * *

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[19] *Pituitary Extract:* The hypophysis, or pituitary gland, is found at the base of the brain. It contains a number of substances which may be extracted. One of these when injected into the body checks the flow of urine, even when large amounts of water are drunk.

Manurial Experiments on Fruit Trees. Mr. T. Wallace continues the description of these valuable experiments in the *Journal of Pomology*, **8**, part 1, January, 1930. The trees are grown in pots in sand cultures and their behavior in complete nutrient solutions is compared with their behavior when the nutrient supplied is deficient in either potassium, magnesium, or calcium. In this present paper, very full ash analyses of the pruned shoots over a period of three years are given. Characteristic effects were produced by the omission of each element. Potassium deficiency led to increased shoot growth, leaf scorch, and defoliation of shoots from tip to base. Calcium and magnesium omission both led to reduction of shoot growth after the first season and to severe breakdown of leaf tissue. The results of magnesium deficiency were especially severe and were reflected in a much lower percentage of dry matter on fresh weight, and thus possibly to a high percentage of ash on dry matter; the calcium and potassium omission series showed a reverse effect—a relatively high dry weight, and low ash content on dry weight. Mr. Wallace directs attention to the wide variations in the ash constituents in the bark and wood of shoots and main stems. The ash is relatively uniform in the bark from both shoot and main stems, but the percentage of ash in the one-year shoots is approximately twice as high as in the wood of the four-year-old stems.—*Nature* (London)

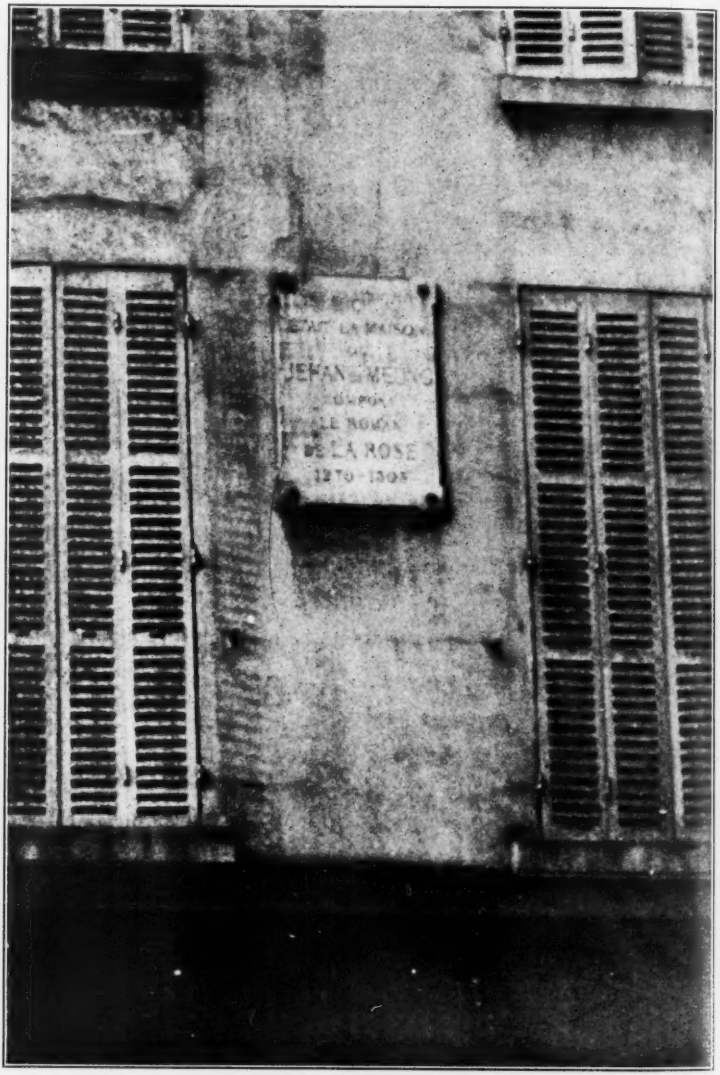
JEAN DE MEUN AND ALCHEMY

FREDERIC WALKER, NEW BRIGHTON, STATEN ISLAND, NEW YORK

The work of Jean de Meun, the brilliant author of the latter part of "The Romance of the Rose," has fallen into almost as complete an obscurity as the facts of his life which, except for a few scant details, have been irretrievably lost. This is unfortunate since the man not only occupies an important place in the history of French literature but also deserves a place in the history of science.

This celebrated French poet was born in the year 1250 or thereabouts at Meun-sur-Loire. Following the custom of the times he took his name from the city of his birth but was also given the surname of Clopinel (the Halt) due doubtless to a limp. He is said to have studied at the University of Paris and later to have come into prominence at the court of Philippe le Bel. He acquired considerable wealth, a prodigy for a poet in that day (or for that matter in any day), and possessed a house in Paris on the Grande Rue St. Jacques. This house was surrounded by a garden and was called *L'Ostel de la Tournelle* on account of its tower. It is here that he died in the year 1305 or slightly before, as it is described at that time as the house of the late Jean de Meun. . The building was destroyed during the civil wars in the sixteenth century and on its emplacement now stands No. 218 of the Rue St. Jacques, an ordinary house of the late eighteenth or early nineteenth century, not distinguished in any way except for a memorial tablet on the wall.

In or about the year 1277, Jean de Meun brought to a rather surprising conclusion "The Romance of the Rose," which was begun about forty years earlier by Guillaume de Lorris and was left unfinished by his early death. He did this by adding to his predecessor's 4669 lines of verse, more than 18,000 of his own. The poem, as begun by de Lorris, was a pastoral idyll written in the allegorical manner which was the prevailing fashion of the times. The object of the poem was to tell how the lover personified in the poet was to win his beloved. The beloved was symbolized as a rose. Various allegorical characters such as Envy, Greed, Danger, Nature, Fear, and Fair-Welcome throng the pages. However, instead of continuing in the idyllic mood of de Lorris, Jean de Meun made of the work an encyclopedia of all the knowledge and theories that pulsed through his brain. In it he placed pell-mell his ideas on the universe, life, religion, science, and morality, and presented a scathing satire on many of the institutions of his day. Thus from a simple allegory of rural love, the "Romance" became a cosmic review of the knowledge of an age and an outspoken summary of the nascent changes in human thought. It is thus plainly evident that in "The Romance of the Rose," as written by Jean de Meun, we have to deal with a document of considerable importance in the history of science.



Courtesy of Mildred Updyke

TABLET MARKING THE SITE OF THE POET'S HOME

The inscription reads: *Ici Était La Maison ou Jehan de Meung Composa Le Roman de La Rose 1270–1305.*

Besides "The Romance of the Rose," Jean de Meun was the author of several other poems, among which are "*Le Tresor ou Les Sept Articles de la Foi*," a "*Testament*," and "*Codicille*." He translated the letters of Abelard and Heloise, Boetius' "*De Consolatione Philosophiae*," and the "*De Re Militari*" of Vegetius. Two other translations have been lost. Other works have been attributed to his hand but the majority of these are undoubtedly spurious. Among these are several chemical works, and the fact that these have been attributed to him attest to the high position accorded to him by the adepts of this art. One of these, "*Le Miroir d' Alquimie*," mentioned by Lenglet du Fresnoy is a French translation of Bacon's "*Speculum Alchimiae*." Another, a long poem entitled "*La Complainte de Nature à l'Alchimiste Errante et la Reponse de l'Alchimiste*," of which we shall have more to say is apparently the work of a later hand, although influenced by "The Romance of the Rose."

Alchemy flourished throughout the reign of Philippe le Bel and it is not surprising to find that Jean de Meun with his scientific trend of mind should become interested in this science. In "The Romance of the Rose," he devotes eighty-four lines to alchemy and gives a clear and succinct outline of its principal theories. He begins by mentioning some of the obstacles to the art or arguments advanced by those who did not believe in the possibility of the alchemistic claims. This is done somewhat after the fashion of Geber in the "*Summa Perfectionis Metalorum*." The general idea of these arguments is that man cannot equal Nature and make metals as she does in the mines. Further, it is stated that to change one metal to another it would be first necessary to reduce it to its *materia prima*, a superhuman task. Finally, even if man could obtain the *materia prima*, he would not be able to prepare the elixir which would change the base metals into gold since the proportions of the elements necessary in its preparation are unknown. After this introduction the author states that notwithstanding, alchemy is a true art, *ars veritable*, and intimates that it may be learned by studying Nature. The whole philosophy of "The Romance of the Rose" is naturalism and this exhortation to follow Nature appears continually. The author now comes to the support of alchemy with the argument that species can be transmuted and supports his statement with examples. These examples will be seen in the translation of this passage which is given below together with the original lines as found in the Méon edition of "The Romance of the Rose."

How is it then that from the fern	*Ne voit-l'en comment de fogiere*
Both ash and clearest glass is made	*Font cil et cendre et voirre nestre,*
By those most learnéd in the trade?	*Qui de voirrerie sunt mestre,*
Can simple depurations turn	*Par depuracion legiere?*
The fern to glass? Glass is not fern	*Si n'est pas li voirre fogiere,*
Nor does the fern exist in glass.	*Ne fogiere ne rest pas voirre.*

In springtime too when clouds amass	*Et quant espar vient en tonnoire,*
And lightning flashes in the squall	*Si repuet-l'en sovent vèoir*
How is it stones are seen to fall	*Des vapeurs les pierres chèoir*
From clouds to which they never rise?	*Qui ne monterent mie pierres?*
Only the scholar may surmise	*Ce puet savoir li cognoisseries*
The reason matter thus may go	*De la cause qui tel matire*
From form to form, but all may know	*A ceste estrange espece tire.*
That these are species greatly changed	*Ci sunt especes très-changiées*
In all their attributes estranged,	*Ou le pieces d'aus estrangiées*
In form and substance set apart;	*Et en sustance, et en figure;*
One by Nature, one by Art.	*Ceus par Art, ceste par Nature.*

Having given these examples of transmutation, Jean de Meun remarks that these changes are great compared to the change of metal to metal, for metals are all one matter made by Nature from sulfur and quicksilver. The base metals can be turned to gold by purging them of their combustible sulfur (*i. e.*, by removing their tendency to rust) and treating them with spirits that will permeate them and become fixed, adding color and weight. "He who can do this may have his will of metals," remarks the author and one must admit the truth of his proposition. The poet also states that gems can be made of fine gold but here we find him at variance with the generality of alchemists. In Lacinius's abridgment of the "*Margarita Preciosa*" of Peter Bonus, written in 1330, we find this idea decried as folly. The section on alchemy is brought to a conclusion with the remark that the false alchemists who work by sophistications and do not follow Nature will accomplish nothing though they work as long as they live.

This sketch of alchemy shows that Jean de Meun was not unread in hermetic literature and justifies the high opinion that adepts of the art later bestowed upon his books. Bernard Palissy, writing in an age when the claims of alchemy were falling into disrepute, in citing the foremost books of alchemy mentions together as of equal rank "*les livres . . . . de Raymond Lulle, de Paracelse, du Roman de la Rose.*" In E. O. von Lippmann's book, "*Der Entstehung und Ausbreitung der Alchemie,*" the author makes mention of the scientific importance of "The Romance of the Rose" and gives a translation in German verse of the portion dealing with alchemy.

"The Complaint of Nature" of which we have previously made mention is an alchemical treatise written in the allegorical fashion of "The Romance of the Rose." The influence of the latter poem is made especially evident by the fact that here and there throughout its length, lines occur which were taken bodily from this poem. These lines are pointed out in the Méon edition of "The Romance of the Rose." The poem begins by telling how nature one day fell into a dispute with an alchemist who used only the mechanical art and made no attempt to follow her teachings. The complaint then follows in which Nature tells the alchemist of his folly, exhorts him to repent and indicates the path that he must follow if he wishes to

JEAN DE MEUN

This picture appears in the Méon Edition of "The Romance of the Rose."

succeed. A second part follows, giving the response of the repentant alchemist who mentions the difficulties he has encountered, thanks Nature for enlightening him, and promises to follow her teachings in the future. A brief epilogue summarizes what has happened and supplies the happy ending by telling that by following Nature's instructions the alchemist finally achieved "the great work."

The alchemical teaching of "The Complaint of Nature," is that Nature makes gold in the closed vessel of the earth from the philosophic sulfur and mercury by means of a gentle heat. In this the alchemist can follow her by preparing these elements and placing them in a closed furnace warmed with a gentle fire. Nature will then do her work, the active and passive will combine and gold will be generated. The philosopher's stone and potable gold can be made if Art and Nature are joined. The preparation of the philosopher's stone is to be carried out with one matter in a single vessel. No positive element is capable of action without the corresponding passive.

The burden of the poem is the oft-repeated admonition to follow Nature, found also in "The Romance of the Rose," but here developed in a manner more consonant with the run of alchemical texts. This exhortation seems at first sight to be an admonition to the scholastic scientist to leave his books and learn by experiment but as may be seen above the situation is not quite so hopeful. This theme was indeed quite common among the alchemists. Ferdinand Hoefer speaks of it as follows in his "*Histoire de la Chimie*," "We observe that the alchemists of the middle ages were in accord already on the necessity for the observation or, as they expressed it, for 'the imitation of Nature.' However this was for them only the means of understanding the secrets of the philosophers." Nevertheless there are times when "The Complaint of Nature" seems to sound a more hopeful note and one feels that faulty as it was, it was a step in the right direction and even in its theory was not wholly devoid of reason. The tirades against the erring alchemist for example are especially pungent and should certainly have not been without effect.

The following quotations will give some idea of the style of the poem which displays considerable verve and is written in a pleasant and moving manner. It will also be observed that the French is plainly not the thirteenth century French of Jean de Meun but is much more like the modern language. The first selections are taken from the opening lines of Nature's speech to the Alchemist (Méon text, new translation).

I speak to you, fantastic sot,	*Je parle a toy, sot fantastique,*
Who call yourself, and yet are not	*Qui te dis et nomme en pratique*
Philosopher, Alchemist too,	*Alchimiste et bon Philosophe;*
You've not the stuff, you never knew	*Et tu n'as scavoir, ny estoffe,*
The theory nor science of it,	*Ne theorique, ne science*

This art, nor yet of me one whit.	*De l'Art, ne de moy cognoissance.*
You break alembics, beast of lead,	*Tu romps alambics, grosse beste,*
The charcoal fumes have turned your head.	*Et brusle charbon qui t'enteste:*
* * * * *	* * * * *
In your hot fires that burn so bright	*Par ton feu si chault qu'il ard gent,*
Quicksilver is not fixed aright;	*Cuides tu fixer vif argent,*
Then too, the quicksilver you use	*Cil qu'est volatil et vulgal,*
Is base and volatile, I choose	*Et non cil dont je faiz metal?*
Another, by your folly caught	*Povre homme, tu t'abuses bien!*
In this way you must come to naught	*Par ce chemin ne feras rien,*
* * * * *	* * * * *
Help me and I will help you,	*Ayde-moy et je t'ayderay:*
As you work, will I work too.	*Comme tu feras, je feray,*
This for my own sons I've done	*Ainsi que j'ai faict à mes fils*
That their profit might be won,	*Dont ilz ont receu les profitz,*
For they always followed me,	*A cause que sans vitupere*
Father, mother, blamelessly	*Ont ensuivi et mere et pere,*
Obeying always my commands.	*Obéissans à mes commans;*
You may see it for it stands	*Com tu peulx véoir ès Romans*
In the books of Jean de Meun,	*De Jean de Meung, qui bien m'appreuve,*
Reproof of sophist, my praise sung.	*Et tant les sophistes repreuve.*
Thus did Arnold, Raymond too,	*Si faist Ville-Neuve, et Raimon*
And he a noble sermon drew;	*Qui en font notable sermon,*
Morienus, the Roman sage,	*Et Morien le bon Romain*
Worked wisely in his day and age.	*Qui sagement y mist la main*
So Hermes labored, him they call	*Si fist Hermés qu'on nomme pere,*
Father and master of them all;	*A qui aulcun ne se compare:*
Geber, likewise played his part,	*Geber, philosophe subtil,*
Writing well of this my art,	*A bien usé de mon oustil,*
In splendid books he won his fame,	*Et tant à escript de beaulx dictz,*
And many others I do not name,	*Et d'autres plus que je ne diz,*
In this all-noble science have shown	*De ceste très-noble science,*
The needed proof and made it known	*Lesquels par expérience*
That this great art is real and true,	*Prouvé que l'art est véritable,*
Well worth the praise that is its due.	*Et la grande vertu et lõuable.*

The following quotations come from the latter part of the Alchemist's reply which brings the poem to a conclusion.

I know my art is folly now,	*Je congnois que c'est grant folie,*
Loss, waste, and labor, I allow;	*Enfin perte et merencolie*
The fiery furnaces are wrong,	*De s'amuser à ces fourneaul,*
The quicksilver and waters strong.	*En vif-argent, en fortes eaulx. . .*
* * * * *	* * * * *
Yet how can I proceed aright	*Et comment me pourray-je guider,*
Unless you aid me with your might?	*Si vous ne me voulez aider?*
You say that I must search for you,	*Puis dictes que vous doiz ensuivre.*
But in this quest, what book will do?	*Je le veulz bien, mais par quel livre?*
One says you must take that or this,	*L'ung dict: Prens cecy, prens cela;*
Another says, 'tis all amiss;	*L'autre dict: Non, laisse-le là;*
Their words are divers and oblique,	*Leurs mots sont divers et oblique,*
Sentences senseless and antique.	*Et sentences paraboliques.*

In truth, the message that they bring	*En effet, par eulx je voy bien*
Is this, I'll never learn a thing.	*Que jamais je n'en sçauray rien.*
* * * * *	* * * * * *
Lady, I thank you from my heart,	*Si vous remercie, ma Dame,*
Body and soul their thanks impart.	*Du corps, et du coeur, et d'ame.*
* * * * *	* * * * * *
Your teachings I will not forsake,	*Je suivray vos enseignemens,*
The elements alone I'll take;	*Et feray que des élémens*
The tincture, I will have, 'tis true,	*J'auray celle noble taincture,*
Nature, by help of God and you.	*Moyennant Dieu, et vous, Nature.*
Thus ends the Alchemist's reply,	*Cy finist la Response toute*
Made with a great uncertainty,	*Que l'Artiste fist en grant doute*
To Nature who became his friend	*Devant Nature sa maistresse,*
And brought him riches in the end.	*Dont il eut enfin grant richesse.*

This alchemical poem acquired considerable fame among the adepts of the hermetic art and was widely read. In the autobiography of Denis Zachaire, first printed in Antwerp in 1567, the author tells us that he studied, "the 'Crowd of Philosophers' (*Turba Philosophorum*), the good 'Trevisan,' the 'Complaint of Nature,' and divers other treatises" in his search for the elusive philosopher's stone. Later a Latin prose translation of the poem entitled, "*Demonstratio Naturae: quam errantibus chymicis facit, dum de sophista et stolido spiratore carbonario conqueritur. Descripta per Joannem a Mehung,*" was published at Frankfort in 1625 in the "*Musaeum Hermeticum*" and in the "*Musaeum Hermeticum Reformatum*" (Frankfort, 1749).

However, as we have stated previously, it appears that this poem was not the work of Jean de Meun but a forgery of later date. We shall now take up the evidence which leads us to this conclusion. Although in the case of "The Romance of the Rose" more than two hundred manuscripts are known, apparently none are known for "The Complaint of Nature" and what evidence there is points to the conclusion that the poem was not extant earlier than the first part of the sixteenth century. Frato Ludovico, who made a study of the alchemistic poetry attributed to Jean de Meun [*Archivum Romanicum Nuova*, **3**, 321–6 (1919)], tells us that the poem is included in a collection of alchemical tracts in the Royal Library of Bologna. This collection was put together in Paris during the first half of the sixteenth century and is the earliest edition of the poem to which we have been able to find reference. Another early edition of the poem is to be found in a book entitled, "*De la Transformation Metallique,*" which contained three alchemical treatises in French verse. This book was published at Paris in 1561, a later edition appeared at Lyons in 1618. M. Méon includes "The Complaint of Nature" with the works of Jean de Meun in his edition of "The Romance of the Rose" but states that he does not know on what authority it has been attributed to his authorship and that he has been un-

Courtesy of Mildred Updyke

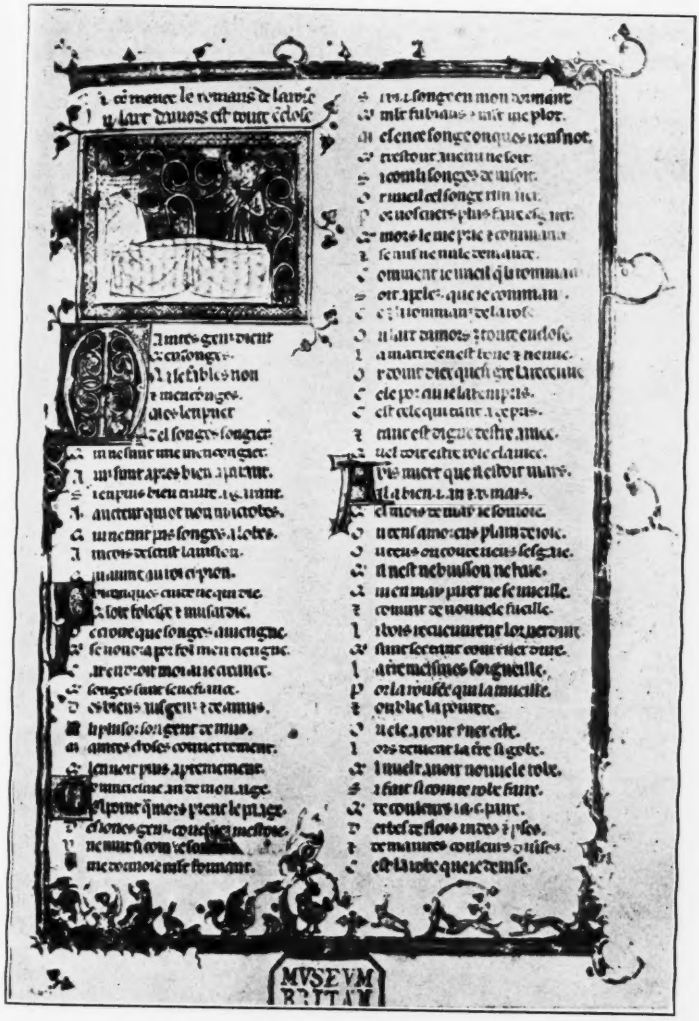
THE HOUSE NOW OCCUPYING THE SITE OF JEAN DE MEUN'S PARIS HOME

able to find manuscripts. In an earlier edition of "The Romance of the Rose" which appeared in 1735 and was edited by the Abbé Lenglet du Fresnoy, "The Complaint of Nature" was also included. In this case the inclusion seems quite natural in view of the editor's hermetic bias. In the Abbé's, "*Histoire de la Philosophie Hermetique*," there is a biographical account of Jean de Meun in which "The Complaint of Nature" is named among his works but no proof is given for the statement.

We have previously called attention to the fact that "The Complaint of Nature" is written in a more modern idiom than "The Romance of the Rose." The poem is in fifteenth or sixteenth century French whereas "The Romance of the Rose" is written in the language of the thirteenth century. Of course, there is a possibility that "The Complaint of Nature," as we know it, is the modernized form of an earlier text but this does not seem probable in view of the fact that the edition of the poem studied by Frato Ludovico, which is the earliest edition to which we have reference, is shown by excerpts given in Ludovico's paper to be identical with the text of Méon's edition. Further, as M. Méon points out, the poem is not in the style of Jean de Meun and it is not in his manner of versifying.

In the quotations given from "The Complaint of Nature," it will be noticed that Nature cites "Raymond" as one of the great alchemists. This "Raymond" is undoubtedly the renowned Raymond Lully and the fact that he is mentioned in the poem as a famous alchemist gives us a further piece of evidence in favor of our theory that the poem was not written by Jean de Meun. Raymond Lully, the Christian philosopher, who was known as Doctor Illuminatissimus, was a contemporary of Jean de Meun but the alchemical books attributed to him were of a later date, and undoubtedly spurious. In a book entitled "Raymund Lully" (London, **1922**), A. E. Waite shows that these books were written subsequent to 1315. Cremer's "Testament" which was long believed to be a contemporary reference to Lully as an alchemist has been shown to be a fraud. Cremer signed himself as the Abbé of Westminster and the records have shown that there was no Abbé of Westminster of this name. Accordingly, since Jean de Meun died in 1305 the reference to Raymond, the alchemist, in "The Complaint of Nature" makes it seem probable that the poem was the work of a later hand.

It thus appears that "The Complaint of Nature" was not the work of Jean de Meun but was written in the early part of the sixteenth century. The evidence supporting this theory may be summarized as follows. (1) No manuscripts of the poem have been discovered. (2) We have been unable to find any references to the poem which date earlier than the first part of the sixteenth century, although later references are quite plentiful. (3) The poem is written in fifteenth or sixteenth century French whereas Jean de Meun's "Romance of the Rose" is written in thirteenth century



A MANUSCRIPT OF "THE ROMANCE OF THE ROSE"

One of the earliest manuscripts of "The Romance of the Rose" (Royal-Ms. 19, B XIII) found in England at the end of the fourteenth century. This manuscript is now in the British Museum. At the top of the page it reads:

Ci commence le romans de la rose Here begins "The Romance of the Rose"
Ou l'art d'amours est toute enclose. In which the art of love is all enclosed.

French. (4) The style and manner of versifying are not in the manner of Jean de Meun. (5) The poem refers to Raymond Lully as an alchemist although the alchemical books attributed to him did not appear until after the death of Jean de Meun.

* * * * *

In bringing this paper to a conclusion the author wishes to make an acknowledgment of his indebtedness to Prof. Tenney L. Davis and Mr. D. B. Wyndham Lewis. The first suggested that this paper should be written for publication and kindly assisted in the proof reading; the second very graciously supplied information concerning the Paris home of Jean de Meun.

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Nitrogen Fixation by Bacteria. The question as to whether or not the nodule bacteria of leguminous plants can fix atmospheric nitrogen independently of their host has always been a vexed one, the results previously obtained by a large number of workers being decidedly conflicting. It is, therefore, of particular interest that three papers have recently appeared on this subject within a few weeks of each other by independent workers, all of which are unanimous in their conclusion that no fixation of nitrogen occurs apart from the host plant. F. E. Allison (*J. Agr. Research*, **39,** p. 893), working with 31 strains of legume-nodule bacteria, grown in a large number of media, under a variety of conditions, has obtained consistently negative results. His conclusions were based on nearly a thousand analyses determined by the Kjeldahl method. E. W. Hopkins (*Soil Science*, **28,** p. 433) gives a useful tabulated summary of all previous investigations, results, and working conditions. He also obtained no evidence of nitrogen fixation from any of the five hundred analyses carried out with the Davisson-Parsons method. M. E. Löhnis (*Soil Science*, **29,** p. 37) has also obtained a negative answer to the question, employing in some experiments the Gunning-Arnold and in others the ter Meulen micro-method for the nitrogen determinations. It would seem particularly convincing that all three workers have secured similar results although each used entirely different methods.—*Nature* (London)

THOMAS MESSINGER DROWN

R. D. BILLINGER, LEHIGH UNIVERSITY, BETHLEHEM, PENNSYLVANIA

Some day a history of American education will be written which will adequately show the influence of the scientist on our higher education. The influence of the chemist will rank high in any such historical summary.

A number of our eminent educators have been chemists. Among these were Eliot of Harvard, Remsen of Johns Hopkins, and Smith of Pennsylvania. To this list may be added the name of Drown of Lehigh.

THOMAS MESSINGER DROWN

Thomas Messinger Drown's career was distinctly academic. Trained as he was at no less than five universities—three in this country and two abroad—he was ably fitted for a life of teaching and research. His immediate influence as an educator was extended to three institutions of learning for almost equal intervals of time—to Lafayette College as professor of chemistry (1874–81); to the Massachusetts Institute of Technology as professor of chemistry (1885–95); and to Lehigh University as president (1895–1904).

His influence, however, reached much farther. To the analytical chemist of the metallurgical and mining industry he was known for his help in devising shorter methods of chemical analysis. Again through his important work in the field of sanitation he became an authority on this subject. Most of this work was done for the State Board of Health of Massachusetts. And to the engineers of the country he is known as one of the founders of the American Institute of Mining Engineers, for ten years (1873–83) its secretary and later (1897–98) its president.

Certainly a life so rich in contacts and so full of service commands our interest and esteem. A review of Dr. Drown's career helps us to understand much better the trend of technical education in the latter part of the nineteenth century.

Drown was born in Philadelphia, March 19, 1842. His father, William Appleton Drown, was a prominent merchant in that city. The parents had come from Portsmouth, New Hampshire. Thomas was the youngest of three sons. His early schooling was in the public schools of Philadelphia, where he began to show his love of books and desire for learning.

While still a boy he became interested in chemical science and set up a small laboratory at home. Certain experiments must have been objectionable to the other members of the family, and soon the little laboratory was moved to an adjoining building where odors would offend none but the young scientist. Drown's father did not attempt to curb his son's efforts entirely (it is doubtful if he could have done so) but he tried to make him thoughtful of the rights of others.

After graduation from the Philadelphia High School in 1859, Drown entered the medical department of the University of Pennsylvania. His choice of medicine was made after considering the possibilities of a future in this profession compared to the apparent scarcity of demand for chemists. His study of medicine, therapeutics, and surgery was followed with zeal and his thesis, "An Essay on Urological Chemistry," was highly praised.

While Drown was at the University of Pennsylvania the chair of chemistry and natural philosophy was held by Professor John F. Frazer (1812–72), a student of the celebrated Dr. Robert Hare. The curriculum was still largely influenced by the work of Hare, whose lectures and text had been among the best in America some thirty years before (*1*).

In 1862 Drown received the degree of Doctor of Medicine, but his practice in this field was to be short. He obtained a position as surgeon on a packet steamer traveling between Philadelphia and England but made only one round trip. A humorous story of his voyage was afterward related by Drown. Upon returning to port he reported to the ship's owner, a Philadelphia Quaker, that he had gotten all of his passengers safely across. The Quaker replied that he had nothing to boast of since most physicians arrived with more.

After his brief medical experience Dr. Drown decided that chemistry would be his life study. The next six years were devoted to intense study under some of the most prominent chemists in this country and Europe. First he worked with Professors Brush and Johnson at the Sheffield Scientific School in New Haven, and then, attracted by the analytical work of Wolcott Gibbs, he went to the Lawrence Scientific School in Cambridge. Dr. Gibbs was able to give him some real chemical problems in the separation of the rare earths. His association with Gibbs, to which he was

always proud to refer, influenced his method of teaching in later years. Much of his ability to impart the spirit of investigation to students, he attributed to his own training with Professor Gibbs.

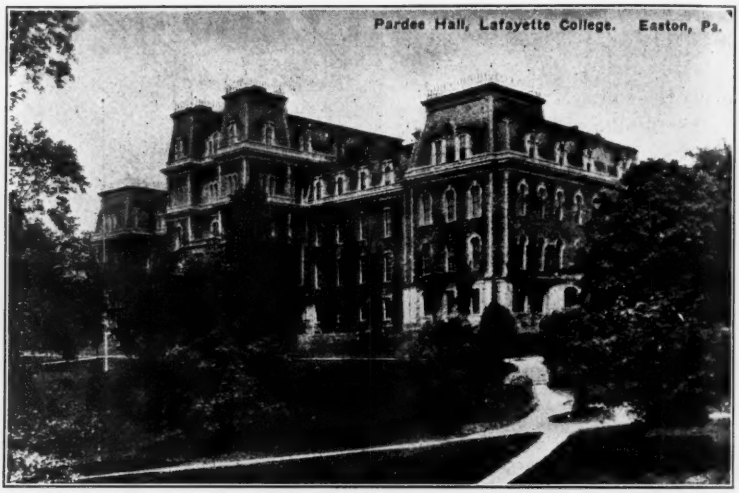
DROWN AS A STUDENT IN GERMANY

Next we find Drown abroad devoting about three and one-half years to study, first at the School of Mines, at Freiberg, Saxony, and later at Heidelberg. At Freiberg there was Plattner, the master of blow-pipe analysis, and at Heidelberg Drown became a pupil and friend of the great Bunsen. To work in the laboratories of these famous institutions was a great advantage to the student of chemistry about 1865. Even today a period of graduate study abroad is recommended, but then it afforded experience not obtainable elsewhere. Contact with the great teachers of chemistry at a time when the science was making rapid changes and developments, was an invaluable aid to American students.

During Dr. Drown's stay in Heidelberg he met Miss Helen Leighton, and in 1869 they were married at her home in Leamington, England.

Upon returning to America in 1869 he accepted a position as instructor in metallurgy at the Lawrence Scientific School, but in 1870 he resigned and went to Philadelphia to work as an analytical and consulting chemist. Most of his work was done in conjunction with Dr. F. A. Genth, a German chemist, who had come to Philadelphia as professor of chemistry in the University of Pennsylvania and who also conducted a laboratory where various types of consulting work were done. This experience afforded Dr. Drown a wide range of materials for investigation and put him in touch with many industrial problems. A humorous story which Drown told of this period with Dr. Genth concerned the analysis of some whiskey. Genth requested the firm for which the analysis was being done to send up five gallons of whiskey. Drown asked him if that much was necessary. "Oh, no," said Genth, "but I'll be able to use it all right."

In 1874 Lafayette College called Dr. Drown to become professor of chemistry in Easton, Pennsylvania. Here he remained until 1881 and



this period was rich in the development of his teaching experience and in the associations formed both at the college and with chemists and engineers throughout the Lehigh Valley.

During this period of his life the American Institute of Mining Engineers was being organized, and the early history of the society was largely the record of work done by Drown and his intimate associates. The Institute was organized in May, 1871, at a meeting at Wilkes Barre, Pennsylvania, and he was one of the original body of twenty-two mining engineers and metallurgists. Active from the start, he was at first one of the board of managers, and then the active secretary during the years 1873–81. The latter position was one requiring an immense amount of work in correspondence, issuing publications, arranging meetings, and all the numerous details which arise. One instance of his faithfulness to his task is attested by his heroic and successful efforts to preserve the Institute's records from a fire which threatened them. In June, 1879, a fire broke out in Pardee Hall, at Lafayette College. It was on the fourth floor of this building where the library and records of the Institute were housed. Dr. Drown hurriedly organized and directed the removal of the most important records and back volumes of the *Transactions*. The work was done by students and others who responded to the cool example of their director. But in the swiftness of the conflagration there was no time left for Dr. Drown to save his own professional library and apparatus, and so his treasures were sacrificed for others which he deemed more precious to the Institute. That the members of the Institute appreciated the great work of Dr. Drown is evidenced by the testimonial dinner which was tendered him several months later at

Montreal, September 18, 1879. Through the efforts of several of his friends (Eckley B. Coxe, Frank Firmstone, and R. W. Raymond) money was collected from Dr. Drown's friends and associates to help reimburse him for his personal loss. This came as a complete surprise following an address by Dr. Raymond. It was humorously presented in the form of a note as follows:

To the Cashier of the Seventh Ward Bank:

Sir:

The undersigned would thank
You to pay, cash down,
To the order of T. M. Drown,
The sum which follers
Three thousand dollars.
Yours, with pleasure,
R. W. Raymond, Treasurer

Dr. Drown was partial to laboratory rather than classroom instruction. His method of close contact with students followed the old peripatetic style where master and pupil talked and worked side by side. This required small classes and was much easier in the early days of chemistry than later. He taught his students to criticize their work and also to study closely the accepted analytical procedures. He was always alert for improved methods and believed that research should be started early in the student's career (*2*).

> The student should live in the atmosphere of investigation. There should be no separation of beginners, advanced pupils and professors, but all should work together as far as possible. No teacher is primarily interested in teaching who does not like to have students about him when he is experimenting.

Drown not only preached research. He practiced it. During his busy career as a teacher and secretary of the Institute he found time to write some fifteen articles. These dealt with determinations of sulfur, phosphorus, silicon, and titanium and aluminum in pig iron and steel; notes on coal-washing and metallurgical processes. Dr. Hart has said "there was hardly a corner in iron-analysis which he did not explore and illuminate. So rapid is progress that some of his work has been lost sight of; but it is there; and it all counted in the present-day development." Besides these researches there were large numbers of notes and comments on work of other investigators; helpful criticism which kept interest in the *Transactions* of the Institute from lagging.

Dr. Drown was fortunate in the formation of early friendships which helped him through life. Two of his closest friends were Coxe and Raymond, prominent mining engineers, who were closely connected with education. Coxe was a trustee of the neighboring Lehigh University, while

DR. DROWN AT THE AGE OF 37

Raymond was a lecturer on economic geology at Lafayette College. This trio had much in common. All had studied abroad at Freiberg. Coxe and Drown were native sons of Philadelphia and were graduates of the University of Pennsylvania. Their combined interests were centered in the Institute of Mining Engineers. They all acted at various times as president of that society.

Dr. Raymond once said of the students who were trained by Dr. Drown, "Drown's men were universally recognized as intelligent, practical, and skilful chemists, and were in special demand on that account." Two of the most prominent of these students are Dr. Edward Hart and Dr. F. W. Shimer. Hart was brought to Lafayette by Dr. Drown and succeeded Drown as professor of chemistry at that institution. Dr. Shimer was an assistant to Dr. Drown from 1879 to 1885 and later became prominent as a consulting analytical chemist. Both of these gentlemen have furnished the writer with many interesting sidelights and facts for this biographical sketch. The high esteem in which Dr. Drown was held is witnessed by this quotation from a letter from Dr. Hart:

> I never had a better or kinder friend. I was happy enough to be an invited guest to tea nearly every Sunday evening at his house. After tea Davy King, John Meigs and Frank Firmstone usually came in and spent the evening. Sometimes Eckley B. Coxe and R. W. Raymond were on hand. Then we made a night of it and wonderful gems of merriment and learning flew thick and fast. They were all notable men and I said nothing but drank in all the nectar. To me Drown's friendship was a benediction and the good-will of his friends little less.

In 1881 Drown resigned from Lafayette and in 1883 he also resigned as secretary of the Institute. The council accepted Drown's resignation and elected him as an honorary member. Thirteen years later he was elected president of the organization which he had worked so hard to build. Dur-

ing his secretaryship the Institute had grown from twenty-two members to thirteen hundred.

For a time he conducted an analytical laboratory on Cattell Street in Easton. Then business conditions in his father's firm in Philadelphia called him away from his profession for several years. The business, the manufacture of umbrellas, had fallen away due to illness of Drown's brother. Dr. Drown reconstructed the business until it could be liquidated and thereby saved the firm name of Wm. A. Drown and Company from bankruptcy. R. W. Raymond says of this period of Drown's life:

> Other men, chivalrously ready to make a similar sacrifice, might have made it in vain; other men, capable of comprehending the business situation, might have refused the quixotic sacrifice; few indeed, I think could have accomplished what Drown did, and fewer still could have remained silent concerning it thereafter.

In 1885, Dr. Drown re-entered the educational field when he accepted the professorship of analytical chemistry at the Massachusetts Institute of Technology. His success here is shown by his appointment as head of the chemistry department in 1888 and in 1893 he also assumed charge of the course of chemical engineering. The laboratory where he worked had been opened in 1876 under the direction of Professors Eliot and Storer (*3*). Other prominent chemists who had directed the work at "Tech" were James M. Crafts, William Ripley Nichols, Charles H. Wing, and Lewis M. Norton. It was no easy matter to keep up a standard as high as that set by his predecessors, but Drown threw the whole weight of his experience into his task and built up a large and successful department, which included twenty-one instructors and five hundred students. He still spent many hours in visiting the laboratories and personally advising his students, but larger classes forced more lecture work upon him, a condition which he regretted because he liked to be at the student's elbow rather than lecturing to large groups.

The course in chemical engineering at the Institute had been introduced in 1888. When Professor Norton died in 1893, Dr. Drown took over the direction of this new venture. It was not clear what subjects should constitute a course in chemical engineering. Should a chemical engineer be primarily a chemist or a mechanical engineer? The problem was to educate young men who could assist in the construction of dye works, sugar refineries, paper and pulp manufactories, soap works, chemical works, and the many problems where chemistry and manufacturing meet. His friend and colleague, Professor Henry P. Talbot, wrote:

> In this capacity he exhibited clear judgment in the extension of the curricula of these courses demanded by changing conditions; and he encouraged the co-workers of all grades in the department by helpful advice, urging the expansion of the work of the individual and promptly recognizing success and ability by unsolicited recommendations for promotion.

Equally important with Dr. Drown's administrative work and teaching at Massachusetts Institute was his connection with the State Board of Health in the investigation of sources of water supply. In June, 1887, Dr. Drown began this chemical survey, which was done in the Walker Building of the Institute by a group of workers under the immediate direction of Mrs. Ellen H. Richards. Another phase of sanitation work with which Dr. Drown was connected was that of sewage purification. Most of this work was done at Lawrence, Massachussetts, where he traveled almost weekly for eight years. Some $250,000 was spent on these investigations. The wisdom with which the funds were spent is shown by the important results achieved and the attention they have since attracted in the field of sanitation. Dr. Drown was peculiarly fitted for such a survey. In addition to his work with chemists and engineers, his early medical training helped him to understand the work of biologists and the physiological significance of the problem.

The result of this extensive and systematic examination (over 18,000 water analyses were made in ten years) was the construction of a "Map of Normal Chlorine" for the State of Massachusetts. This showed the normal composition of a surface water in any given district. An increase of chlorine over the normal indicated a measure of contamination. This procedure served as a model for other states and the value of the work was widely acclaimed. Most of the reports of this work have been issued in the publications of the State Board of Health of Massachusetts, references to which are made in every authoritative text on sanitation and water analysis. Other papers were written in the *Technology Quarterly* and the *Journal of the New England Water Works Association.*

Sometimes a prophet is honored in his own country. Dr. Drown's early career in the Lehigh Valley, as we have already learned, had won him many influential friends. His successful researches and executive ability demonstrated in Boston had further confirmed the trust of his many early associates. Thus when Lehigh University was in need of a president in 1895, it is not strange that she should have sought the services of Thomas M. Drown. His views on "technical training" were well known to Lehigh, since he had addressed the Alumni Association of the University on that subject in June, 1883 (*2*). When Drown was first approached on the question he said he did not believe "that a majority would look favorably on the selection of a man for president whose training and experience had been mainly scientific and technical." But Lehigh wanted Drown, and the warm appeals of his friends, Eckley B. Coxe, John Fritz, and H. S. Drinker, prompted him to leave his chemistry and accept the larger task of directing the university. When he left the Massachusetts Institute of Technology, General Francis A. Walker said:

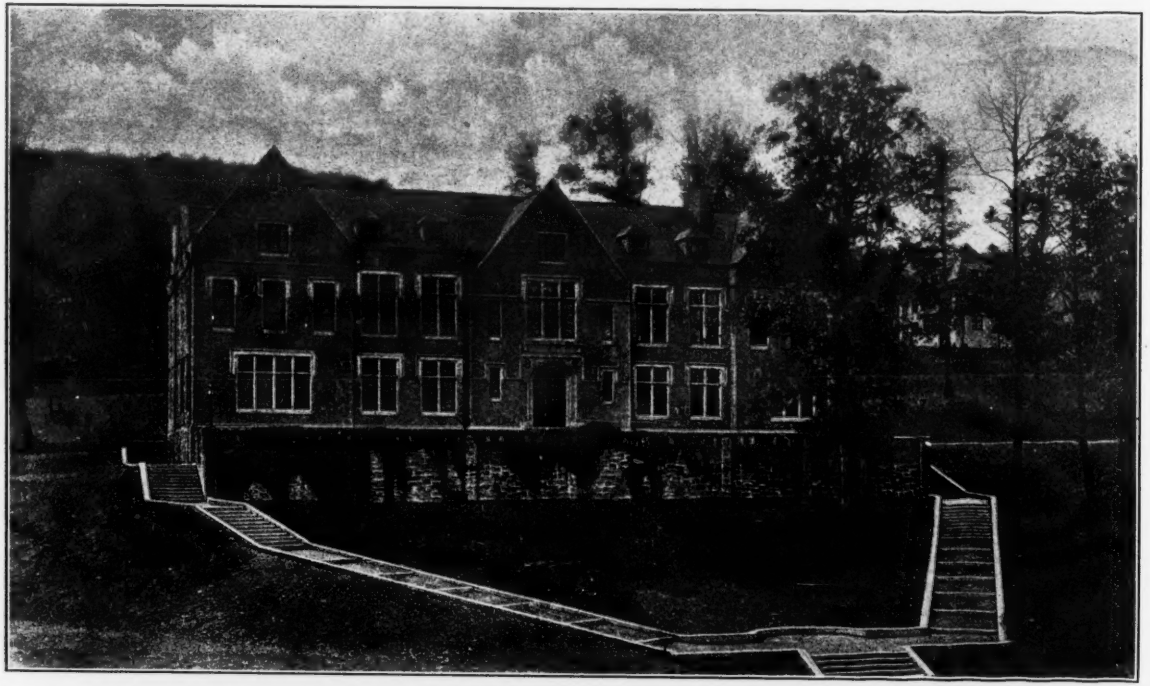
In taking from us Dr. Drown, you have taken a man whose place we do not expect to fill adequately for many years to come. There is no man in the country of more scholarly attainments or greater administrative ability.

On June 19, 1895, Drown was inaugurated as president of Lehigh University. The same month he received the honorary degree of Doctor of Laws from Columbia University. Shortly before he assumed his new duties his good friend E. B. Coxe died. This was a sad loss, because it was largely with the hope of Coxe's coöperation and aid that he had come to Lehigh. Serious financial troubles beset the college, about this period, due to fluctuations in Lehigh Valley Railroad stock, which had been its chief source of endowment. But trustees and alumni rallied to support the new executive. Moreover, Dr. Drown and his capable advisor, H. S. Drinker, appealed to the Pennsylvania state legislature for funds to tide over this critical period and their efforts were successful.

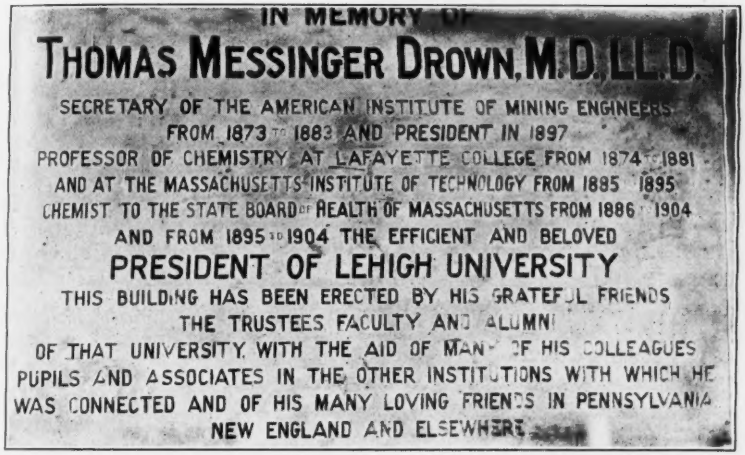
Drown's career as a college head was marked by his endeavors to further develop Lehigh as a technical school. He formulated his ideas in an address, "The Educational Value of Engineering Studies," delivered shortly after he accepted his new work. He believed in "a severe drill in mathematical and mechanical subjects, aided by laboratory practice, which permits the student to handle apparatus and machines and to observe the results of his experiments." By this training the student should learn the methods of original research and become a seeker after truth. Side by side with the scientific and technical studies he insisted on the broadening and humanizing influence of cultural studies. If this could not reasonably be done in the normal four-year course, then he would advocate a five-year term.

He believed the prime business of a college was to train students in accurate, logical thinking so as to strengthen their whole mental and moral fiber. He had no sympathy with the "steady increase of luxurious *dilettantism*" which had entered our colleges. Recreations, gymnastics, and athletics were considered healthy and useful in college life, but if limitations were not placed upon them athletics would run riot and take time and thought which should be devoted to study. In addition to training students for various occupations and professions he believed the college should also aim to develop character and prepare for the duties of citizenship. To this end he advocated the study of political economy for all engineering students.

Dr. Drown was a genial and mild-mannered man with an exceptional charm of voice and bearing, and a keen sense of humor. He established most cordial relations in dealing with both the faculty and students. With the hearty coöperation of Mrs. Drown his beautiful home was opened to all who cared to enjoy his hospitality. Despite the cares of an unusually difficult period in Lehigh's history, his secretary, Mr. F. R. Ashbaugh, says he only once saw Dr. Drown give any display of anger. When nettled too



DROWN MEMORIAL HALL, LEHIGH UNIVERSITY, BETHLEHEM, PENNSYLVANIA


IN MEMORY OF
THOMAS MESSINGER DROWN, M.D. LL.D.
SECRETARY OF THE AMERICAN INSTITUTE OF MINING ENGINEERS
FROM 1873 TO 1883 AND PRESIDENT IN 1897
PROFESSOR OF CHEMISTRY AT LAFAYETTE COLLEGE FROM 1874 TO 1881
AND AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY FROM 1885 TO 1895
CHEMIST TO THE STATE BOARD OF HEALTH OF MASSACHUSETTS FROM 1886 TO 1904
AND FROM 1895 TO 1904 THE EFFICIENT AND BELOVED
PRESIDENT OF LEHIGH UNIVERSITY
THIS BUILDING HAS BEEN ERECTED BY HIS GRATEFUL FRIENDS
THE TRUSTEES FACULTY AND ALUMNI
OF THAT UNIVERSITY WITH THE AID OF MANY OF HIS COLLEAGUES
PUPILS AND ASSOCIATES IN THE OTHER INSTITUTIONS WITH WHICH HE
WAS CONNECTED AND OF HIS MANY LOVING FRIENDS IN PENNSYLVANIA
NEW ENGLAND AND ELSEWHERE

BRONZE TABLET IN DROWN MEMORIAL HALL

strongly by a problem he would set it aside for the day and go for a walk. He is said to have been able to see the ludicrous side of petty annoyances, a faculty which is a great boon to any executive.

His active participation in chemistry was curtailed by his administrative duties. However, his interest was still keen. He frequently lectured on scientific subjects and he was able to give very valuable suggestions to the chemistry department at Lehigh. He was also retained as consulting chemist by the Massachusetts State Board of Health and made trips to Boston every few months to act in an advisory capacity.

After nine years of devoted service to Lehigh, Dr. Drown died an untimely death on November 16, 1904, as the result of an operation which had not been considered very serious. While his loss was felt mostly by the university, his death was mourned by friends throughout the entire country. Two years after his death a handsome Memorial Building was erected on the Lehigh campus to remind future generations of the love and respect which he engendered in the hearts of his friends and students. He was succeeded as president by his friend Dr. H. S. Drinker, an engineer-lawyer who carried on many of Dr. Drown's policies.

The breadth of Drown's contacts and the variety of his experiences present us with a many-sided personality. In addition to his accepted and well-known ability in the fields of science and education, he was also a critic of music and literature. Nor did he overlook the claims of citizenship and the activities of the community in which he lived. He was always interested in any cause for the physical, intellectual, or moral uplift of his fellows. As a press clipping states, announcing the news of his death:

He was a constant reminder of the important truth that the specialist need not necessarily be out of sympathy with life in its varied aspects.

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The writer wishes to acknowledge the help of many friends and relatives of Dr. Drown who kindly assisted in furnishing facts, references, and photographs for this article.

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Modern Science Is Not Scientific. A large part of what the public calls science and much of the science teaching in schools and colleges today is not really science, Dr. A. J. Goldfarb, retiring chairman of the medical science section of the American Association for the Advancement of Science, declared at the recent Des Moines meeting. "The extent to which unscientific science is taught in our schools is amazing," he said. "Maltraining like malnutrition, if long continued, has very serious and lasting effects on the organism." Evidence of scientific maltraining may be found in many of the papers sent to scientific journals which must be rejected for major and serious defects.

Science is difficult to define and few educated or "schooled" persons today agree on what subjects may be properly called science, outside of a few broad classifications. "The experimental method, properly defined, characterizes real science and differentiates it from primitive science, from pseudo-science, from non-science, from anti-science," Dr. Goldfarb said. He described the history of the development of science and compared it to the development of the human race, science having had its primitive stages, just as man had. The primitive stage of science included the fact-finding stage and the law-formulating stage, but the experimental stage represents a more complex and modern development. "Collections of facts do not constitute science. At best they are the prelude to science, the building blocks with which the structure of science is built," Dr. Goldfarb said. "To substitute the accumulation of facts and laws or dexterity of manipulation for experimental methodology is naïve, erroneous, anti-science, the cartoon of science."

"Fact and law worship dominate the science courses in nearly all schools and colleges," Dr. Goldfarb said. He believes that the methods of experimental investigation may be pursued long before work is done for the doctor's thesis, and he looked forward to the day when there would be more scientific teaching of science in all schools and closer coöperation between all scientists no matter in what branches they are engaged.—*Science Service*

AN INTRODUCTION TO CHEMICAL CATALYSIS IN HOMOGENEOUS SYSTEMS

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It is part of our daily experience that many chemical reactions which have a strong tendency to take place either do not occur or else occur so slowly that their progress is scarcely perceptible. Wood or other organic material may be kept indefinitely in the presence of air without being oxidized to water and carbon dioxide; in dry air pure iron rusts only very slowly; the oxygen and nitrogen of the air do not combine to convert our seas and lakes into dilute solutions of nitric acid; and on a smaller scale we may keep a pure solution of hydrogen peroxide for some time without having to consider its decomposition, or a solution of sugar without its becoming appreciably inverted. If we wish any of these reactions to take place at a more rapid rate we must either raise the temperature of the system or else add a catalyst. In some cases, when side reactions become important at higher temperatures, the latter method is the only one available.

A catalyst is, by definition, a substance which by its presence in a system may accelerate a reaction without itself undergoing any net chemical change. As is well known, however, a catalyst cannot initiate a reaction which does not have a tendency to take place. In other words, the presence of a catalyst cannot effect a chemical equilibrium. Catalysts can be divided into two classes; (1) heterogeneous or contact catalysts and (2) homogeneous or solution catalysts. The subject of contact catalysis has been extensively studied in recent years, and the results of these investigations have been very clearly summarized by H. S. Taylor in his "Treatise on Physical Chemistry" (*1*). Unfortunately, the subject of homogeneous catalysis is still popularly considered to be shrouded in mystery and to be too complex to permit of any simple analysis. In reality, homogeneous catalysis is no more complex or mysterious than heterogeneous catalysis, though some of its aspects have not been developed as completely as the general field of contact catalysis.

All but the simplest chemical reactions proceed by a series of steps, which are in general bimolecular reactions. The rate of the total or stoichiometrical reaction is determined or limited by that of the slowest step. Most solution catalysts act by accelerating, or more exactly by circumventing, this slowest step. It is very probable that the catalyst unites with the components of the slow reaction step to form an intermediate substance: this intermediate substance then reacts rapidly to give the products of the reaction step and to restore the unchanged catalyst molecule. This is known as the "intermediate-compound theory of catalysis."

For convenience we may divide homogeneous catalysis into three major classes. The oldest and best known of these classes consists of acid and base catalysis, or the effect of acids and bases in accelerating such reactions

as hydrolyses and organic rearrangements. The second class is that of oxidation and reduction catalysis. This includes the action of oxygen carriers. The intermediate-compound theory resulted from a study of reactions of this class. The third class includes the effect of "neutral" (or non-reacting) salts and of the solvents. In recent years the action of neutral salts has been successfully analyzed and systematized by J. N. Brönsted (*2*). At present the nature of the solvent effect is but little understood. Its study has proved very difficult, both from a theoretical and from an experimental standpoint. The field of "negative catalysis" may be included in the first two divisions. Enzyme action is a biological branch of chemical catalysis which is of great importance (*3*). It is apparently closely analogous to acid and base catalysis. Another subject which is at least formally identical with homogeneous catalysis is photosensitization (*4*), or the effect of light-absorbing substances in inducing photochemical reactions in otherwise transparent systems. These photosensitized reactions have been studied both in liquid and in gaseous media: an example of the former is the decomposition of organic acids by uranyl salts in visible light, while the formation of water from its elements in the presence of chlorine in visible or near-ultra-violet light is an example of the latter. Photosynthesis (*5*), or the formation of carbohydrates from carbon dioxide and water in the tissues of chlorophyll-bearing plants, is a naturally occurring case of photosensitization of greatest importance.

Acid and Base Catalysis

One of the earliest systematic investigations of the rate of a homogeneous chemical reaction was Wilhelmy's (*6*) investigation of the effect of acid on the rate of sugar inversion. Using moderate concentrations of strong acids, he found that the rate was directly proportional to the concentration of the acid. This was later interpreted from the standpoint of the Arrhenius theory as evidence that the reaction rate was proportional to the concentration of the hydrogen ions. A number of other reactions, especially hydrolysis reactions, the velocities of which are apparently proportional to the concentration of the hydrogen or hydroxyl ions, have been observed. However, later and more accurate measurements, some of them involving neutral salts or weak acids, indicate clearly that the simple interpretation of Arrhenius is not sufficient to account for the facts. One of the earliest attempts to explain these anomalous results was made in 1907 by Acree, who postulated that not only the hydrogen ion but also the unionized acid is able to act as a catalyst in certain reactions. While this theory seems to have been founded upon a misinterpretation of the experimental facts, it does mark a distinct advance in the study of acid and base catalysis. Before we are in a position to treat acid and base catalysis from the modern standpoint we shall have to consider an extended theory of acids and bases (*7*).

According to the classical definition, an acid is a substance whose aqueous solution has a higher hydrogen-ion concentration than pure water, and a base is a substance whose aqueous solution contains more hydroxyl ions than pure water. Reducing this to symbols, an acid is defined by equation (1), and a base by equation (2):

$$HA = A^- + H^+ \quad (1)$$
$$BOH = B^+ + OH^- \quad (2)$$

These definitions have been generalized by Franklin and his co-workers (*8*) to include other solvents than water. A more general definition of acids and bases has been elaborated by J. N. Brönsted (*9*), who defines an acid as any substance which can emit a proton, and a base as any substance which can unite with a proton. This may be written as

$$A = B + H^+ \quad (3)$$

where A and B are "conjugate acids and bases," and the positive charge on A is greater than that on B by one unit. The following are typical cases of conjugate acids and bases.

$$HAc = Ac^- + H^+ \quad (4a)$$
$$NH_4^+ = NH_3 + H^+ \quad (4b)$$
$$HSO_4^- = SO_4^{=} + H^+ \quad (4c)$$

Many solvents, including water, are capable of acting either as acids or bases. When water acts as an acid,

$$H_2O = OH^- + H^+$$

it forms the base OH^-; when it acts as a base,

$$H_2O + H^+ = H_3O^+$$

it forms the acid H_3O^+, hydronium ion. The free proton has such a strong tendency to unite with any polar molecule that its concentration in any solution containing water is extremely small. Taking this fact into account, the following expressions should be substituted for equations (4*a*), (4*b*) and (4*c*):

$$H_2O + HAc = Ac^- + H_3O^+ \quad (5a)$$
$$H_2O + NH_4^+ = NH_3 + H_3O^+ \quad (5b)$$
$$H_2O + HSO_4^- = SO_4^{=} + H_3O^+ \quad (5c)$$

It follows from this general treatment, that, while hydrogen ions might be expected to play a distinct rôle in catalysis, hydroxyl ion should not differ in its general effect from acetate ion, sulfate ion, unionized ammonia, or any other base. Moreover, the concentration of free protons is negligibly small in all solutions which have been studied, therefore the catalytic effect of strong acids must be due to the hydronium ions (or in general to the solvated protons). Since hydronium ion is an acid similar to ammonium ion or acetic acid, we may expect that any such acid molecule or

ion will be able to act as a catalyst just as hydronium ion. The conclusions based upon this theory may be summarized as follows: (1) Any acid or base may act as a catalyst for certain types of reactions. (2) In any real solution the concentration of protons is so small that their catalytic effect is entirely negligible. (3) There is nothing unique about the action of hydroxyl or hydronium ions. (4) The catalytic effect, measured by the rate constant, is different for each acid or base, and for any given acid is different for each reaction.

The subject of acid-base catalysis has been recently advanced, particularly by the study of three comparatively simple reactions; the decomposition of nitramide (*10*), the mutarotation of glucose (*11*), and the hydrolysis of ethyl orthoacetate (*12*). The rate of the first of these reactions

$$H_2N_2O_2 \longrightarrow H_2O + N_2O$$

was determined by measuring the evolution of the inert gas (N_2O), using an all-glass shaking apparatus and manometer. The rate of the mutarotation of glucose, as well as the rate of the hydrolysis of ethyl orthoacetate

$$H_2O + CH_3C(OC_2H_5)_3 = CH_3CO{\cdot}OC_2H_5 + 2C_2H_5OH$$

were obtained from dilatometric measurements. It should be noted that the products of these reactions do not affect the rates of the reactions directly. This is particularly noteworthy in the last case, since most hydrolyses involve the liberation of an acid or base and are therefore autocatalytic in character. Nitramide decomposes in basic solution but is stable in acid solution; the mutarotation of glucose is catalyzed by both acids and bases; while the hydrolysis of ethyl orthoacetate is readily catalyzed by acids but is not affected by bases. The catalytic effects of acids and bases, other than hydronium ion and hydroxyl ion, have been measured in each of these three cases. The bases used in these experiments include negative ions, ranging from hydroxyl ion to chloracetate and doubly charged sulfate ion, neutral bases, varying in strength from ammonia to orthochloraniline, and positive ions, such as the hydroxypentamine cobaltic ion. The acids used were similarly varied in type, and included ions as well as a wide range of neutral organic acids. A discussion of the way in which the individual specific reaction rates were obtained from the experiments, for the several acids and bases, would be out of place here; these experimental and mathematical details may be found in the original papers (*10*, *11*, *12*).

From an analysis of the results obtained in these series of experiments, Brönsted has shown (*9*) that the specific catalytic constant of an acid (or a base) is a simple function of its dissociation constant. If, for example, the logarithms of the dissociation constants (K_A) of a series of organic acids are plotted against the logarithms of their catalytic constants (k_A), deter-

mined by the measurements on the rate of mutarotation of glucose, the resulting points are found to lie on a straight line. The slope of this line ($\Delta \log k_A / \Delta \log K_A$) is 0.2. The study of the catalytic effect of acids on the hydrolysis of ethyl orthoacetate, and the study of basic catalysis in nitramide decomposition and in mutarotation of glucose, all yield curves of the same general form. The slope of the line is always less than unity and greater than zero. These general results may be expressed by the equation

$$k_A = G_l K_A^x,$$

where G_l and x are constants, the values of which are determined by the nature of the solvent and of the reaction. In all cases x is greater than zero and less than unity.

Probably the best mechanism or "explanation" of acid and base catalysis is Brönsted's "molecular theory" (*9*). This theory is a special case of the intermediate-compound theory of catalysis. It postulates that a complex is formed between the acid (or base) and the reactant. This complex formation is presumably an equilibrium process:

$$\mathrm{HA} + \mathrm{R} = \mathrm{HA{\cdot}R}$$

The slow, or rate-determining, step in the catalytic reaction is the transfer of the proton to the molecule of the reactant:

$$\mathrm{HA{\cdot}R} \longrightarrow \mathrm{A{\cdot}RH}$$

The complex A·RH then undergoes a rapid internal rearrangement, eventually yielding a molecule of the product and returning the proton to a molecule of the catalyzing acid. Basic catalysis can be interpreted as a similar cycle of reaction steps, the second of which is the loss of the proton by the reactant to the basic catalyst. It might be expected that the rate of the second reaction step would be a function of the ionization constant of the acid (*i. e.*, of its tendency to part with a proton). The stronger an acid, the more readily it gives up its proton, presumably as well to a molecule of the reactant as to a molecule of the solvent. Indeed, the empirical relation between the velocity of the catalyzed reaction and the strength of the acid or base ($k_A = G, K_A^x$), may be readily derived from this mechanism with the aid of a few very probable assumptions (*9*).

It is apparent that there are many points of similarity between Brönsted's "molecular theory" of acid catalysis and the "ionization theory" supported by von Euler (*13*) and Stieglitz (*14*). As long as measurements are confined to solutions of strong acids and bases, there is no experimental way of differentiating between them. However, experiments in buffer solutions afford fairly satisfactory evidence in favor of the former theory. Certain reactions are known which seem to involve the simultaneous action of an acid and a base, in aqueous acid solutions the water molecule acting

as a base. It should be pointed out that, while the classifications and predictions of the extended theory of acid and base catalysis can be applied generally, there is no apparent reason for considering the "molecular theory" to be of such a general nature. It is entirely possible that reactions will be found the mechanisms of which will conform to the ionization theory or to some entirely different mechanism. Such results, if they are obtained, will in no way minimize the importance and usefulness of the extended theory of acid and base catalysis.

Oxidation and Reduction Catalysis

The action of oxygen carriers is presented in practically every elementary textbook of general chemistry; usually in connection with the effect of "nitre pots" in the chamber process of manufacturing sulfuric acid. The effect of the oxides of nitrogen in catalyzing the oxidation of iodide ion by gaseous oxygen is a similar but apparently simpler case of oxidation and reduction catalysis. If a small amount of a soluble nitrite is added to a solution of potassium iodide in dilute sulfuric acid, the nitrite is reduced forming a trace of iodine and nitric oxide.

$$2HNO + 3I^- + 2H^+ = 2NO + I_3^- + 2H_2O$$

The nitric oxide, dissolved in the solution, is oxidized by the oxygen which diffuses in from the atmosphere; most probably forming nitrogen dioxide.

$$NO + {}^1/_2\, O_2 = NO_2$$

The nitrogen dioxide, so formed, rapidly oxidizes iodide ion, and regenerates nitric oxide, which is free to take up more oxygen.

$$NO_2 + 3I^- + 2H^+ = NO + I_3^- + 2H_2O$$

It is apparent that the sum of the equations involving nitric oxide and nitrogen dioxide is

$$^1/_2O_2 + 3I^- + 2H^+ = I_3^- + H_2O$$

and this equation represents the stoichiometrical reaction which is actually taking place in the solution. Although the oxides of nitrogen are involved in a series (or cycle) of rapid reactions, these reactions are so balanced that the result is simply an increase in the rate of oxidation of iodide ion by atmospheric oxygen.

Although this case is not readily amenable to quantitative treatment, since one of the reactants is a relatively insoluble gas, it does illustrate clearly the nature of homogeneous oxidation-reduction catalysis. It is very probable that in all cases of oxidation-reduction catalysis the catalyst is present in an oxidized and a reduced form; that is, the catalyst is not a single substance but a *catalytic pair*, in this case nitrogen dioxide and nitric oxide. The mechanism of the catalyzed reaction involves the simultaneous oxidation and reduction of the two forms of the catalyst.

One of the most exhaustively studied cases of oxidation-reduction catalysis is the iodine-iodide catalysis of the decomposition of hydrogen peroxide. While this reaction has been analyzed successfully by Abel (*15*), it is somewhat more complex than the analogous catalysis by bromine and bromide. The bromine-bromide catalysis has been demonstrated, by Bray and Livingston (*16*), to have the following mechanism. In an acid solution hydrogen peroxide oxidizes bromide ion to hypobromous acid at a moderate rate,

$$H_2O_2 + Br^- + H^- = HBrO + H_2O \qquad (1)$$

and reduces hypobromous acid to bromide ion very rapidly,

$$H_2O_2 + HBrO = H_2O + Br^- + H^+ + O_2 \qquad (2)$$

When these two reactions occur at the same absolute rate, the concentrations of bromide ion, hydrogen ion, and hypobromous acid remain constant, and the result, given by the sum of the two preceding equations, is the decomposition of hydrogen peroxide.

$$2H_2O_2 = 2H_2O + O_2$$

The rates of the two reaction steps, represented by equations (1) and (2), can be represented by equations (3) and (4), respectively.

$$v_1 = k_1 (H_2O_2) (H^+) (Br^-) \qquad (3)$$
$$v_2 = k_2 (H_2O_2) (HBrO) \qquad (4)$$

Reactions (1) and (2) have the same absolute rates only when the concentration of hypobromous acid bears a definite relation to that of hydrogen ion and of bromide ion. The form of this relation may be derived in the following manner. Since the absolute rates are the same:

$$k_1 (H_2O_2) (H^+) (Br^-) = k_2 (H_2O_2) (HBrO)$$

and

$$(HBrO) = (k_1/k_2) (H^+) (Br^-).$$

When this condition is satisfied the system is said to be at the *steady state*. Since the specific reaction rate of reaction (2) is much greater than that of reaction (1), k_1/k_2 is a very small number, and the steady-state concentration of hypobromous acid is always extremely small. However, the hydrolysis of bromine is a reversible or equilibrium reaction,

$$H_2O + Br_2 = HBrO + H^+ + Br^-$$

which is so rapid that it maintains the concentration of hypobromous acid at its equilibrium concentration even in an acid solution of hydrogen peroxide. The mass action law for this equilibrium is

$$(H^+) (Br^-) (HBrO)/(Br_2) = 5.2 \times 10^{-9}$$

By means of this relation we may eliminate the concentration of hypobromous acid, which is too small to determine analytically, from the steady state relation.

$$5.2 \times 10^{-9} (Br_2)/(H^+) (Br^-) = (k_1/k_2) (H^+) (Br^-)$$

or

$$(Br_2)/(H^+)^2 (Br^-)^2 = (k_1/k_2) \times 2 \times 10^8 = R \qquad (5)$$

These predictions have been substantiated by a number of experiments. It has been demonstrated that the rates of reactions (1) and (2) are represented by equations (3) and (4), respectively; and that, at the steady state, equation (5) holds and R has the predicted value. It has also been demonstrated that the rate of decomposition of hydrogen peroxide at the steady state is given by the following equation.

$$v_{H_2O_2} = 2k_1 (H_2O_2) (H^+) (Br^-)$$

This is in agreement with the mechanism, since the decomposition of hydrogen peroxide is the sum of reactions (1) and (2):

$$v_{H_2O_2} = k_1 (H_2O_2) (H^+) (Br^-) + k_2 (H_2O_2) (HBrO)$$

and, at the steady state, $v_1 = v_2$; therefore

$$v_{H_2O_2} = 2k_1 (H_2O_2) (H^+) (Br^-)$$

It should be mentioned that the actual measurements are somewhat complicated by the formation of tribromide ion (which is taken into account in the original papers) (*16*) and by a general salt effect, which, however, does not change any of the conclusions presented here and which is discussed in the next section of this paper.

Somewhat similar mechanisms have been demonstrated for the chlorine-chloride catalysis (*17*) and for the iodine-iodide catalysis (*15*) of the decomposition of hydrogen peroxide. In the former case the steady-state reaction can be studied conveniently only in fairly concentrated solutions of hydrochloric acid, and in the latter case only when the hydrogen-ion concentration is held within the limits 10^{-7} to 10^{-6}, by means of buffers. In distinctly acid solutions, the iodine-iodide pair is superseded by an iodine-iodate pair. However, this latter reaction, which has been studied by Bray and Caulkins (*18*), appears to be of a very complex nature. A number of similar reactions could be cited, but the examples given here should suffice to illustrate the type of mechanism involved. The details of the experimental and theoretical methods of studying these reactions are to be found in the original papers.

A distinctly different but very interesting case of oxidation-reduction catalysis is illustrated by the silver-ion catalysis of the reduction of peroxysulfate ion. In the presence of silver ion, peroxysulfate ion oxidizes chromic ion, ammonia in alkaline solution, and ammonium ion in acid solution at measurable rates (*19*).

$$7H_2O + 3S_2O_8^{=} + 2Cr^{+++} \longrightarrow Cr_2O_7^{=} + 6SO_4^{=} + 14H^+$$
$$3H_2O + 4S_2O_8^{=} + NH_4^+ \longrightarrow 10H^+ + 8SO_4^{=} + NO_3^-$$
$$6OH^- + 3S_2O_8^{=} + 2NH_3 \longrightarrow 6SO_4^{=} + N_2 + 6H_2O$$

None of these reactions occur at appreciable rates in the absence of silver ion. The rate equations for all of these reactions have the same form.

$$v = k\,(S_2O_8^{=})\,(Ag^{+})$$

The concentration of the reducing agent has practically no effect on the rate. The value of the rate constant (k) is about 0.3 for the first two reactions, but is about eight times greater for the third reaction. The explanation of these facts was first indicated by Jost (*19*), who demonstrated that the slow, or rate-determining, reaction step is the formation of a trivalent silver compound:

$$S_2O_8^{=} + Ag^{+} \longrightarrow Ag^{+++} + 2SO_4^{=}$$

The trivalent silver compound, one form of which may be isolated, is a powerful and reactive oxidizing agent. It is rapidly reduced by chromic ion, ammonia, and ammonium ion. According to this mechanism, the rate of the stoichiometrical reaction is independent not only of the concentration of the reducing agent but even of its chemical nature. This is in perfect agreement with measurements of the rates of the oxidation of chromic and of ammonium ion. Some of the possible explanations for the eight-fold greater rate observed in alkaline ammonia solutions have been discussed by Jost (*19*) and by King (*20*). None of these suggestions conflict with the general mechanism involving trivalent silver. It should be mentioned that peroxysulfate, in the presence of silver ion, is reduced much more rapidly by oxalic (*20*) acid than by any of the three other reducing agents studied. Since the measurements of the rate of this reaction were not reproducible it is not possible to establish a kinetic equation from them. A possible explanation of these results, as well as of certain minor peculiarities in the other reactions, has been suggested by Livingston (*20*), in terms of a relatively inactive complex between the silver ion and the peroxysulfate ion (similar to the well-known thiosulfate complex ion). Another possible explanation might be based upon the assumption that the oxidation of oxalic acid by peroxysulfate ion is essentially a *chain reaction.*

Although the detailed mechanism of "silver ion catalysis" differs considerably from that of the halogen-halide catalysis of the decomposition of hydrogen peroxide, it should be noted that in both cases the catalyst was present as a *catalytic pair;* in the first case, $Ag^{+} - Ag^{+++}$, in the second case $X_2 - X^{-}$ (or $HXO - X^{-}$). It seems fairly certain that during the steady state of all such catalytic reactions the catalyst exists in two forms, and that the rate of the reaction is determined by the rates of the balanced transformations of the two forms of the catalyst into one another. At the steady state of such a process the absolute rate of these two balancing reactions must be equal. Examples in which the catalyst seems to exist as one molecular species only, are limiting cases in which the specific reaction rate of the disappearance of this form of the catalyst is comparatively

very small. This interpretation of oxidation-reduction catalysis makes it possible to predict (*16*) suitable possible catalysts for any given reaction. In order for a given catalyst to be effective, both the oxidation of its reduced form by the oxidizing agent involved and the reduction of its oxidized form by the reducing agent must have a tendency to take place. It is possible to determine if this be true whenever the oxidation potentials of the two oxidation-reduction couples are known (even approximately). Needless to say, the fact that such a condition is satisfied is not proof that the catalytic pair in question will be effective, since either or both of the postulated reaction steps may be slow. On the other hand, if a given catalytic pair does not satisfy the energy condition we may be sure that it will not be effective as a catalyst.

While the occurrence of *negative catalysis* is not limited to oxidation and reduction reactions, some of the more interesting cases occur in this field. It has been pointed out by Tithoff (*21*) that the stabilizing effect of a negative catalyst is frequently due to the removal by it of a small quantity of some positive catalyst. For example, the rate of a hydrolysis reaction, which is markedly catalyzed by acid but not by base, would be greater in ordinary distilled water than in a dilute solution of sodium hydroxide. In this case the *negative catalytic* action of the base is due entirely to the reduction of the concentration of hydronium ions (normally present in water or due in part to traces of impurities such as carbon dioxide). A second type of negative catalysis, sometimes called inhibition, was first successfully interpreted by Christiansen (*22a*). This type of negative catalysis is limited to exothermic reactions of the *chain* type. A chain reaction is a reaction in which the heat produced by the reaction between a pair of molecules is utilized directly to *activate* another pair of molecules. It follows that the rate of a chain reaction depends partly on the number of chains started (for a thermal reaction, upon the temperature) and partly upon the average length of the chains. The inhibitor acts by absorbing the energy produced by the reaction between a pair of molecules, thus preventing it from being used to activate a new pair and so breaking the chain. It has been demonstrated (*22b*) that, in the oxidation of sodium sulfite, one molecule of the inhibitor (*e. g.*, benzyl alcohol) is oxidized for each chain broken. This theory of the *inhibition of chain reactions* has many important applications in the action of anti-oxidants, etc.

The Kinetic Salt Effect

The kinetic salt effect is a type of catalysis which is more general in character. The velocities of practically all reactions occurring in solution are affected by the presence of electrolytes. This effect is produced not only by added "inert" or "neutral" salts but by all ions present in the solution, including the reactants and products. This effect is greatest

for reactions between ions, and is especially noticeable when the total salt concentration is low.

A similar effect observed in the study of chemical equilibria was successfully interpreted by G. N. Lewis (*23*). The following discussion is intended to give only a general idea of this subject. The classical mass action law for the reaction:

$$A + B = M + N$$

may be written as

$$K_c = C_M \times C_N / C_A \times C_B$$

where C_A, C_M, etc., are the concentrations of the reaction components. It has long been known that the quantity K_c does not remain exactly constant when the concentrations are varied, particularly if one or more of the reactants are ions. It is obvious that the left-hand side of the equation may be rendered constant by multiplying each of the concentration terms by an appropriate factor, f.

$$K_a = \frac{C_M \times C_N}{C_A \times C_B} \times \frac{f_M \times f_N}{f_A \times f_B}$$

In this expression, K_a, unlike K_c, is a constant, independent of the concentrations of the reactants and of the total salt concentration. The factor f is called the activity coefficient. The activity coefficient is a function of the nature of the molecule or ion and of the solvent, but is not dependent upon the nature of the reaction being considered. The term solvent is used here in the sense of "thermodynamic environment," and includes not only the pure solvent but also everything else present in the solution. For very dilute solutions the activity coefficient of an ion depends only on the charge on the ion and on the nature of the solution. For this case Debye and Hückel have deduced the following equation,

$$\log f = -0.5\, z^2 \sqrt{\mu}$$

where z is the charge on the ion, and μ is a quantity called the ionic strength (*24*), and defined as half the sum of the products of the stoichiometrical molalities of the ions and the squares of their charges.

After it had been demonstrated that the introduction of activity coefficients into the mass action law eliminates the anomalies from chemical equilibria, it was suggested that this should also be true for the classical reaction velocity equation:

$$v = k_c \cdot C_A \cdot C_B$$

However, this suggestion ignores the experimental fact that in dilute solution the activity coefficients of all ions decrease with increasing ionic strength, while the specific reaction rate, k_c, of various reactions increase, decrease, or remain practically constant. It was first pointed out by Brönsted (*2*) that the reactions whose specific reaction rates decrease are

those involving two ions of unlike sign, those which increase involve ions of like sign, and those which remain practically constant involve either an ion and a non-electrolyte or else only non-electrolytes.

To explain this observation Brönsted postulates that all reactions involve the formation and decomposition of an unstable intermediate complex, as is indicated by the following equation.

$$A + B = X = N + M$$

A simple, though possibly not the most exact, way of developing this theory is to assume that the reactants, A and B, are in rapid reversible equilibrium with the intermediate substance, X, so that its concentration is maintained at a small but steady value, which is determined by the mass action law:

$$C_x = K_x \cdot C_A \cdot C_B \cdot f_A \cdot f_B / f_x$$

This intermediate substance undergoes slow spontaneous decomposition into the reaction products, M and N. The rate of this process may be represented by the expression

$$v_{MN} = k_x \cdot C_x$$

Substituting for the unknown, C_x, we may write

$$\begin{aligned} v_{MN} &= (k_x \cdot K_x) \cdot C_A \cdot C_B \cdot f_A \cdot f_B / f_x \\ &= k\, C_A \cdot C_B \cdot f_A \cdot f_B / f_x \end{aligned}$$

This expression indicates that the reaction velocity is proportional to the product of the activity coefficients of the reactants and is inversely proportional to the activity coefficient of the intermediate complex. Unfortunately, it is not possible to measure f_x directly. For dilute solutions, where the Debye-Hückel equation holds, we may compute its value, since the charge on the intermediate complex is the algebraic sum of the charges of the reactants.

It follows that for very dilute solutions:

$$V_{MN} = kC_A \cdot C_B \cdot 10^{z_A z_B \sqrt{\mu}} *$$

The three types of kinetic salt effects which have been observed experimentally are clearly indicated by this equation. For reactions between ions of unlike sign the product $z_A z_B$ is negative, and the specific reaction rate should decrease with increasing ionic strength; when the charges on the ions have the same sign (either positive or negative) $z_A z_B$ is positive, and the velocity should increase with increasing ionic strength, but if

* This may be readily demonstrated as follows:

$$\begin{aligned} \log f_A \cdot f_B / f_x &= \log f_A + \log f_B - \log f_x \\ &= 0.5 \sqrt{\mu}\,(z_A^2 + z_B^2 - z_x^2) \end{aligned}$$

But $z_x = z_A + z_B$

Therefore $\log f_A \cdot f_B / f_x = z_A z_B \sqrt{\mu}$

either or both of the reactants is a neutral molecule, $z_A z_B$ is equal to zero and the velocity is independent of the ionic strength. It is a striking fact that there are no definite experimental exceptions to these predictions.

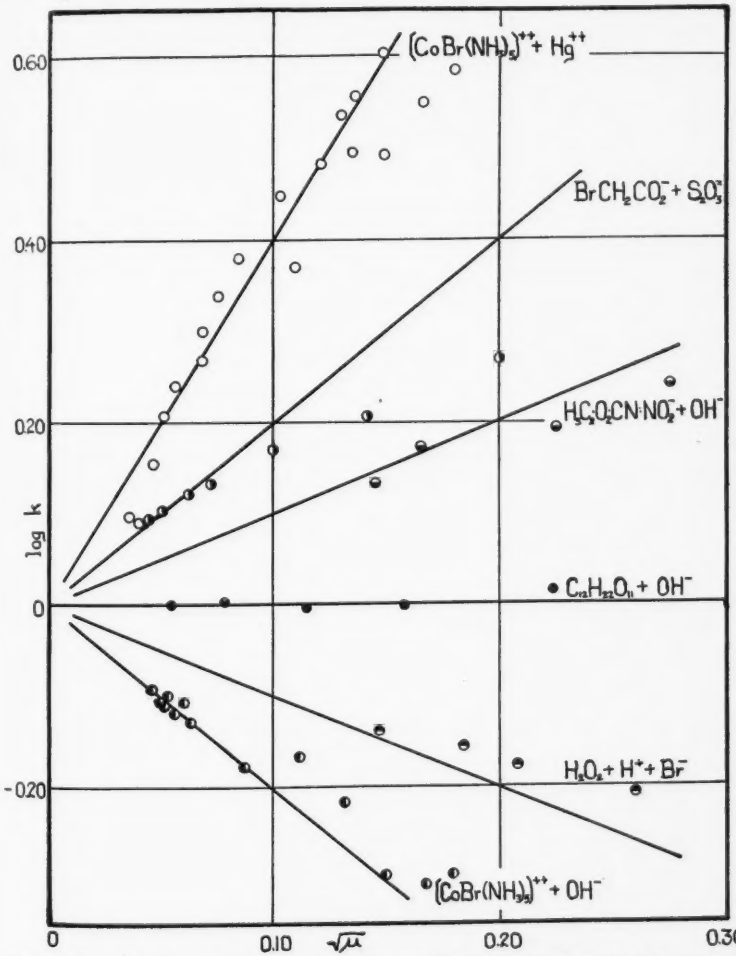

FIGURE 1.—THE EFFECT OF IONIC STRENGTH ON THE VELOCITY OF IONIC REACTIONS

For a quantitative test of this theory there are at present only five cases available; the oxidation of hydrogen bromide by hydrogen peroxide (*25*), the saponification of nitrourethane ion (*26*), two reactions of brom-pentamine cobaltic ion (*27*), and the reaction between thiosulfate by bromace-

tate ion (*28*). For the sake of comparison the results for a reaction with zero salt effect, the inversion of sugar in dilute solutions of sodium hydroxide (*29*), are included. The results of these experiments are represented in Figure 1. The points represent all the experiments in which the added salts were of the uni-univalent type. In this figure the log of the specific reaction rate, k_c, is plotted against the square root of the ionic strength. For each reaction, a constant factor has been added to the values of log k_c to render the value obtained by extrapolation to infinite dilution equal to zero. The straight lines have been drawn through the origin with slopes equal to $z_A z_B$. On the whole the agreement between the experiments and the predictions of the theory are remarkably good. It is noticeable, however, that there is a distinct departure from the laws which hold in extremely dilute solutions at ionic strengths no greater than 0.04 ($\sqrt{\mu} = 0.20$). This is not surprising and should in no way weaken our confidence in the correctness of the theory.

While it is not possible to obtain an exact quantitative confirmation of the theory for more concentrated solutions, Brönsted has shown (using values of f_x based upon experimental average values) that the agreement is quite satisfactory up to ionic strengths at least as great as 0.2 or 0.3. For certain classes of reactions, particularly those where the intermediate complex is a neutral molecule, the theory may be applied to reactions occurring in much more concentrated solutions (*30*). One interesting prediction of the theory is that kinetic anomalies (of the salt effect type) may be eliminated by using low concentrations of the reactants in the presence of a large constant concentration of inert salt. This prediction has been substantiated by experiment (*31*). In general, it is almost impossible to exaggerate the importance to the study of reaction kinetics of Brönsted's theory of the salt effect.

All of these phenomena are sometimes classified under the heading of the primary salt effect. The presence of salts may also affect reaction velocity by changing the degree of ionization of any weak electrolytes involved in the reaction; this is called the secondary salt effect (*2*), (*9*). Since most weak electrolytes are either acids or bases, the secondary salt effect is of importance chiefly in acid and base catalysis. The thermodynamic dissociation constant of a weak acid may be written (if the change in activity of the water is neglected) as:

$$K_A = \frac{C_{A^-} \cdot C_{H_3O^+}}{C_{HA}} \times \frac{f_{A^-} \cdot f_{H_3O^+}}{f_{HA}}$$

For all neutral or negatively charged acids the quotients of the activity coefficients decrease for an increase in ionic strength, in the dilute solution range. Since K_A is a constant there must be a corresponding increase in the concentration quotient. In cases where C_{HA} is large compared to

$C_{H_3O^+}$ (as in a solution of acetic acid) this increase in the concentration quotient is due almost entirely to the increase in the concentration of the base (acetate ion) and of the hydronium ion. In other words, the addition of a salt to the solution of a weak acid results in an immediate increase in the concentration of the hydronium ions; and therefore, in the presence of a system catalyzed by acid, of an increase in the reaction velocity, not explicable in terms of the primary salt effect. For acids with a single positive charge (*e. g.*, ammonium ion) the secondary salt effect is practically zero; for acids with two or more positive charges it is negative. The secondary salt effect also applies to weak bases and to buffer solutions, though its application to buffer solutions is somewhat more complex. While the secondary salt effect is not of as great general importance as the primary, it has proved to be extremely useful in the interpretation of experimental studies of acid and base catalysis.

Solvent Catalysis

Of the several types of homogeneous catalysis, solvent catalysis is at present the least understood and the least predictable. Although there has been considerable progress since the subject was first studied by Berthelot and Saint Gilles (*32*) in 1862, we are still far from having a clear understanding of the effect of solvents on the rate of chemical reactions occurring in them.

It is very probable that solvents affect reaction velocities in two distinct ways (*33*); first, by determining the values of the activity coefficient of the reaction complex, and second by some other mechanism, possibly by changing the rate of the spontaneous decomposition of the reaction complex. The first effect amounts to a generalization of the *salt effect.* It is frequently, though not always, possible to predict the direction and order of magnitude of this effect; since the activity coefficient of the reaction complex may be estimated either by assuming the validity of the Debye-Hückel (*34*) or the Debye-MacAuley (*35*) equation or by analogy with known substances which are assumed to have the same physical properties.

It has been suggested variously that the second type of solvent effect is a function of either the viscosity or the dielectric constant of the solvent. There seems to be very little theoretical justification for the assumption that the velocity should be a function of the viscosity, and it has been demonstrated by a wide variety of experimental tests that the velocity is not appreciably affected by a change in the viscosity of the solvent. The experimental results on the effect of the dielectric constant are much less definite. In general, it seems that reactions go more rapidly in polar solvents (*i. e.*, solvents of high dielectric constant) than in non-polar solvents. However, it has not yet proved possible to establish any functional relation between the dielectric constant and the effect on reaction velocity.

It should be pointed out that here, as in the discussion on acid-base catalysis, *solvent* is used in the sense of *thermodynamic environment.*

In addition to the purely catalytic effect of the solvent, the rate and even the nature of certain reactions may be affected by the direct participation of the solvent in the reaction. For example, the direct bromination of organic unsaturates very probably involves the bromine molecule as such, while in aqueous solution the brominating agent may be hypobromous acid, formed by the hydrolysis of bromine. The possibility of effects of this sort, as well as possible association or dissociation of the reactant molecules, and the difficulty of obtaining certain solvents free from traces of more polar substances, makes exact experimental work in this field very difficult.

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Zinc Sulfate Treatment Kills Weed Seeds without Injuring Sprouting Trees. A method of chemical weeding for seedling beds of evergreen trees has been worked out at the Northern Rocky Mountain Forest Experiment Station at Missoula, Montana. According to W. G. Wahlenberg, formerly of the U. S. Forest Service, who describes the work in detail in a new technical publication of the U. S. Department of Agriculture, this method saves 27 per cent of the cost of producing two-year-old tree seedlings, besides saving many young trees that would be destroyed or damaged by the old laborious process of hand weeding.

The new method, as worked out during several years past at the Savenac nursery, consists in applying one and one-eighth ounces of zinc sulfate dissolved in one quart of water to every four square feet of seedbed soil. This attacked and poisoned the roots of the weeds as they tried to leave the germinating seeds. The roots of the sprouting evergreens were more resistant and were not injured. The situation was roughly analogous to that in the blood of a malaria patient who takes quinine. The drug kills the germs but does not harm the body tissues.

During the experiments other chemicals were tried, but zinc sulfate proved to be the most effective. Higher and lower concentrations of the zinc sulfate were also tried, but the higher concentrations sometimes injured the tree seedlings, and the lower ones were not so effective against the weeds. "The concentration to be used for best effect must depend partly on the nature of the soil," Mr. Wahlenberg says. A finer-grained soil than the one at Savenae would require more of the sulfate, a coarser-grained soil less.

The method is not without its disadvantages, which must be guarded against. The sulfate tends to make the soil acid, and liming will need to be carried on in some localities to correct this. If the soil is stirred after applying the sulfate to the surface the effect is lost; weeds sprout readily in spaded or plowed places after treatment. Fresh treatment of a seed bed is therefore necessary every time a new lot of tree seeds is planted.

One incidental advantage seems to come from the treatment. After the seedlings are taken up and the soil re-plowed, field peas are frequently planted as a green manure crop. The residual zinc in the soil does not injure the peas but rather increases their growth, apparently through encouraging the colonies of nitrogen-fixing bacteria on their roots.—*Science Service*

THE MAKING AND USE OF TETRAHEDRA MODELS

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If the student of organic chemistry has before him tetrahedra models he seldom fails to visualize space isomerism, the asymmetric carbon atom, and the effect on polarized light of compounds having this configuration. The use of these models makes unnecessary much blackboard work involving drawings representing tetrahedra and so relieves the instructor of a task at which he may not be very adept. The tetrahedra pictured in this article are easy to construct and the time consumed is well repaid by the quickness with which the student grasps the idea and the short time necessary for the presentation of the subject when tetrahedra models are shown. The results are well worth the trouble.

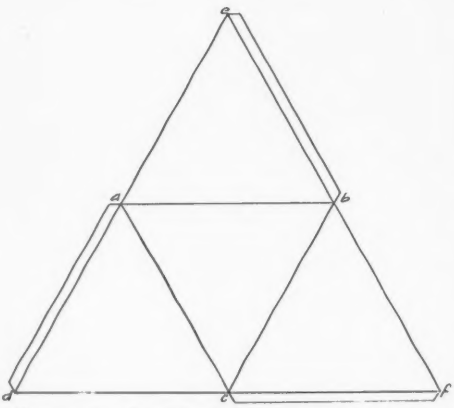


FIGURE 1.—SHOWING PATTERN FOR REGULAR TETRAHEDRON

An equilateral triangle *d e f*, say 8″ on a side, is first laid out on medium weight stock. If each side is bisected at *a*, *b*, and *c* as shown in the figure, the resulting tetrahedron will have edges 4″ long. Flaps are left to assist in gluing the edges together, for which purpose Duco Household Cement is very satisfactory as it dries so quickly. Having laid out the tetrahedron as shown in Figure 1, run a knife along the line *ab*, *bc*, and *ac*, but do not cut through the stock. Do the same along the flaps *be*, *ad*, and *cf*. This will give straight edges when the cardboard is bent, leaving the cut on the outside. Glue is applied to the flaps and the tetrahedron is formed by bringing *e*, *f*, and *d* together. It is well to reënforce the edges with mending tape. Dennison's No. 3 mending tape which is $^3/_4$″ wide is very convenient. To apply the tape, cut the length required, crease it through the middle lengthwise, making the crease sharp by pressing down on it with the flat side of a knife blade. By using mending tape it is not necessary to wait for the glue to set.

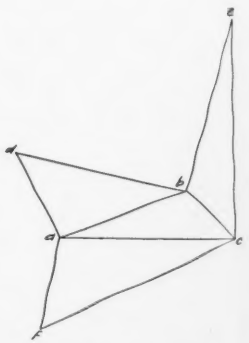
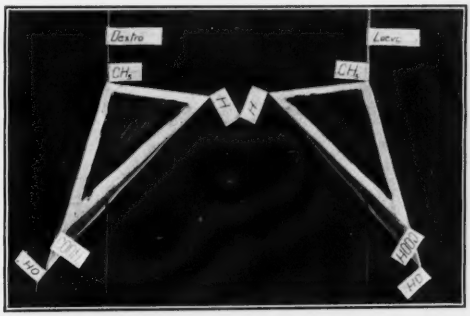


FIGURE 2.—SHOWING PATTERN FOR IRREGULAR TETRAHEDRON

The construction of irregular tetrahedra is somewhat more troublesome. Referring to Figure 2, lay out the triangle *a b c*, in which no two sides are alike in length. With *c* as a center and with another length describe an arc for the sides *ce* and *cf*. Again with *a* as a center, with yet another length describe a wide arc cutting one of the previous arcs at *f*, thereby establishing the sides *cf* and *af*. Finally, using *b* as a center and with still another length describe another wide arc which will cut the arcs previously drawn at *d* and *e*, thereby establishing the sides *bd* and *be*. On folding, the points *f*, *d*, and *e* will come together and an irregular tetrahedron will result. Call this a "right." To construct the corresponding "left" is an easy matter, making the "left" a mirror image of the "right." It will be well to mark them *R* and *L* if several are to be made and to use the first drawings as templates, marking the points with a pin. On connecting the points, cut along the lines



MODELS OF LACTIC ACIDS

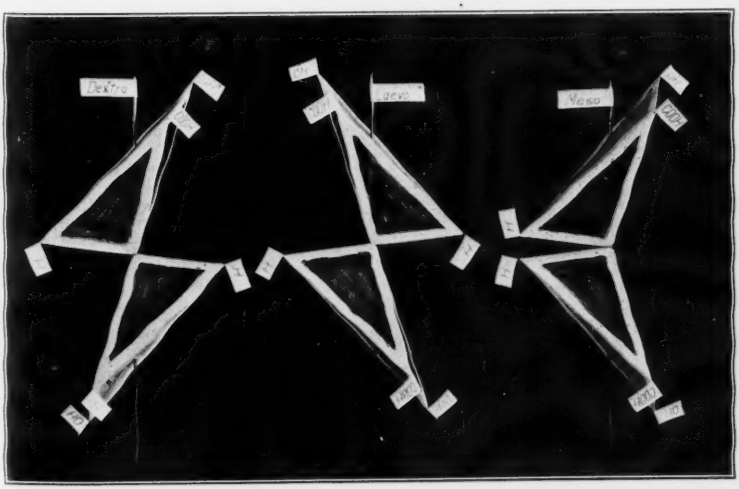


FIGURE 3A.—MODELS OF TARTARIC ACIDS
Compare line drawings of Figures 3 and 4, page 2906.

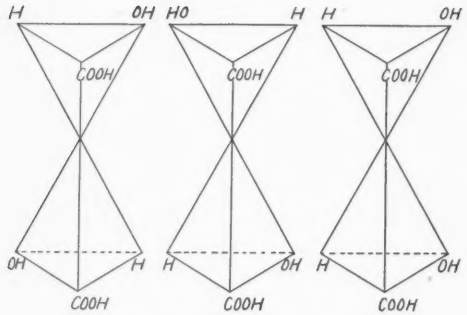


FIGURE 3.—CONVENTIONAL LINE DRAWINGS OF TARTARIC ACIDS

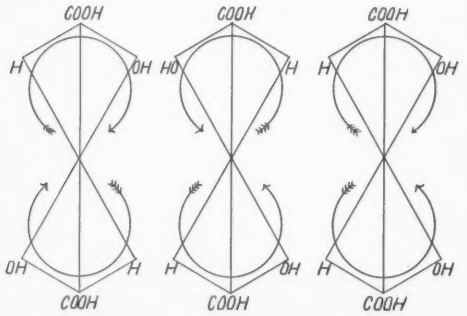
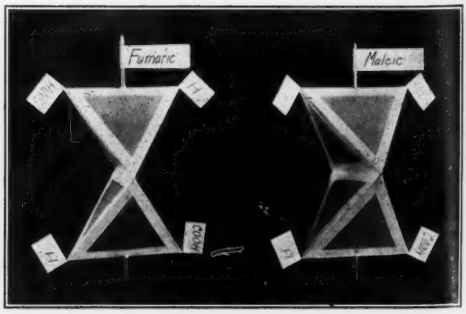


FIGURE 4.—PLANE REPRESENTATION OF TARTARIC ACIDS

with a little flag made from the mending tape and pins. On page 2905 is a photograph showing a "right" and a "left" tetrahedron marked to represent dextro and levo lactic acid, the right-handedness and left-handedness of which are readily seen.

The use of tetrahedra models to represent the tartaric acids are given in the photograph marked drawn for folding and always fold away from the drawn lines. It is better not to cut flaps for the distorted tetrahedra but to use creased mending tape for joining the edges. The distorted tetrahedra produced from the mirror image layouts will be related as a pair of gloves, giving a "right" and a "left." These would represent a pair of asymmetric carbon atoms. As a working hypothesis, it may be imagined that the substituting groups take up positions at distances from the center of the tetrahedron according to the nature of the group. These positions are represented by the corners of the tetrahedron. The particular substituting group may be marked



MODELS OF MALEIC-FUMARIC ACIDS

Compare line drawings of Figure 5, page 2907.

Figure 3*A*, with the conventional line drawings in Figure 3. To make up the tetrahedra models from the appropriate "rights" and "lefts," choose one solid angle to represent the carbon-to-carbon linkage. In the plane opposite this solid angle locate the center by bisecting each edge and drawing a line from this point to the corner opposite. Do this with each of the tetrahedra to be mounted, being careful to use the proper "rights" and "lefts" and to choose similar planes and solid angles.

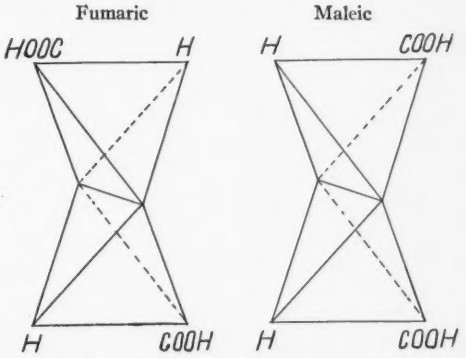
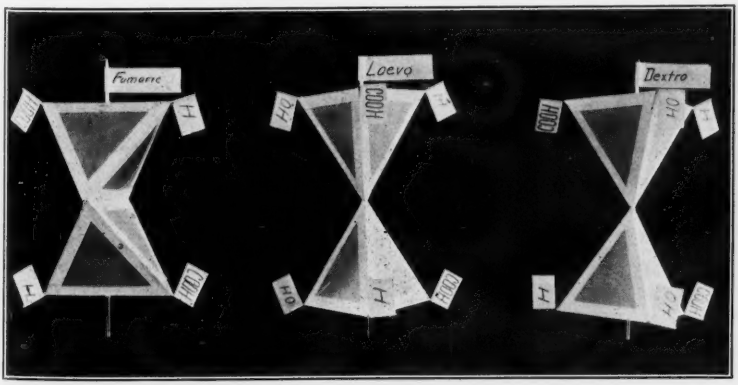


FIGURE 5.—CONVENTIONAL LINE DRAWINGS OF FUMARIC AND MALEIC ACIDS

If the tetrahedra of the line drawing of Figure 3 were imagined as being flattened out in the plane of the paper, the configurations might be represented by Figure 4. Let it be imagined that polarized light is rotated in a clockwise direction by the groups taken in the order H, COOH, OH, and $C_2H_3O_3$, and suppose a "right" to be such a combination; then the rotation of polarized light caused by the upper tetrahedron of dextro tartaric acid is augmented to the same extent by the lower tetrahedron and the combination is dextro rotatory, each tetrahedron contributing equally to the total rotation. The same discussion applies to the levo form of tartaric acid,



MODELS SHOWING OXIDATION OF FUMARIC ACID

Compare line drawings of Figure 6, page 2908.

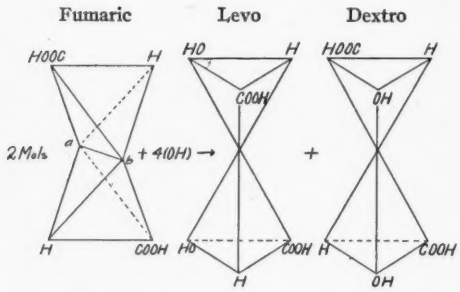


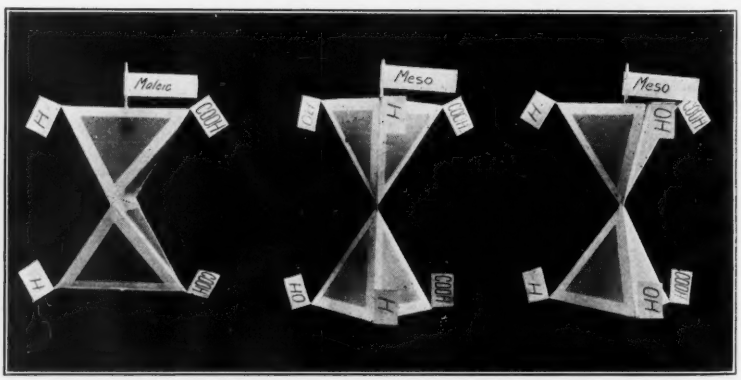
FIGURE 6.—CONVENTIONAL LINE DRAWINGS SHOWING OXIDATION OF FUMARIC ACID

which on the same assumptions would give to polarized light a counter-clockwise rotation. If a mirror were placed vertically between the dextro tartaric acid and the levo tartaric acid, it would be seen that each form, as a whole, is a mirror image of the other.

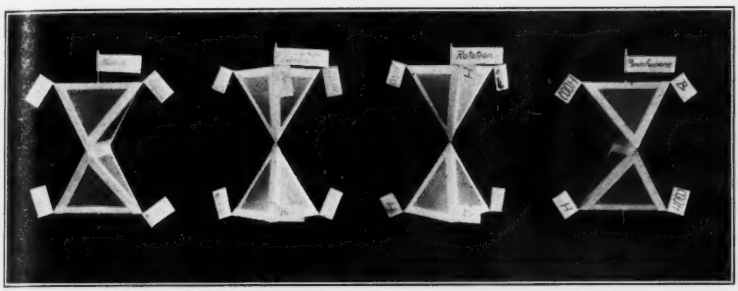
The racemic form, being composed of equimolecular proportions of the dextro and the levo forms, is readily seen to be inactive and the student easily grasps the fact that it can be resolved into two active forms.

The upper half of the meso form we have taken to be dextro rotatory. The lower half is levo rotatory to exactly the same extent, making the molecule optically inactive. That the meso form is inactive due to internal compensation is readily seen. A mirror held horizontally between the upper and lower halves of the molecule would show one-half the mirror image of the other. Such a form could not be separated into optically active constituents.

Tetrahedra are especially useful in showing the fumaric-maleic-tartaric-succinic acid relationship. As we are not dealing here with optical isomerism but with geometrical isomerism, the regular tetrahedra will suffice,



MODELS SHOWING OXIDATION OF MALEIC ACID
Compare line drawings of Figure 7, page 2909.



MODELS SHOWING THE TRANSFORMATION OF MALEIC TO BROM FUMARIC ACID
Compare line drawings of Figure 8.

in fact serve better (*1*). The single bond joining carbon to carbon is represented in the tetrahedra by the touching or joining of the solid angles.

The joining or touching of two tetrahedra, edge to edge, represents a double bond between carbon atoms. Fumaric and maleic acids may be represented by the formulas:

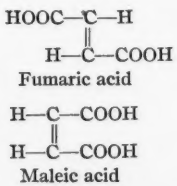


Figure 5 and its corresponding photograph show these acids in the conventional line drawings and in the tetrahedra which make it easy to see that fumaric acid forms no anhydride while maleic acid does.

The process of oxidation may be regarded as equivalent to adding hydroxyl groups:

$$H_2O + O = 2OH$$

On this assumption, the

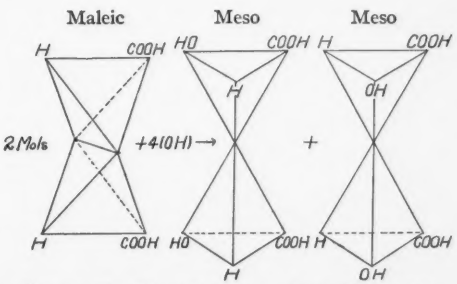


FIGURE 7.—CONVENTIONAL LINE DRAWINGS SHOWING OXIDATION OF MALEIC ACID

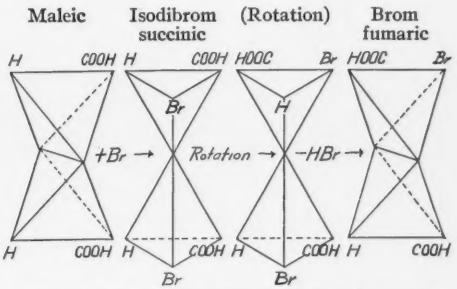
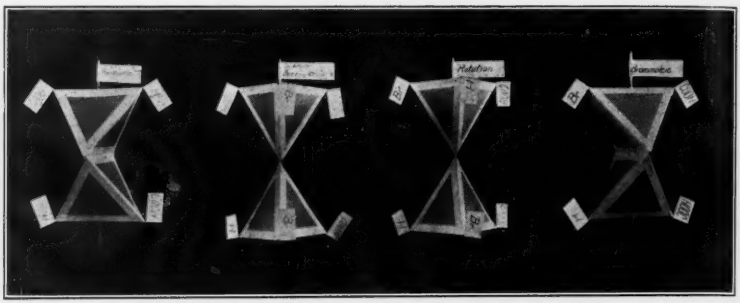


FIGURE 8.—CONVENTIONAL LINE DRAWINGS SHOWING THE TRANSFORMATION OF MALEIC TO BROM FUMARIC ACID



MODELS SHOWING THE TRANSFORMATION OF FUMARIC TO BROM MALEIC ACID
Compare line drawings of Figure 9, below.

first products of the oxidation of fumaric acid may be represented as given in Figure 6 (page 2908).

In order that the hydroxide group may be added, it must find a point of attachment at the corner of a tetrahedron. To get this point of attachment, the double bond must be broken and this break has an even chance to occur at *a* or *b* (see line drawing, Figure 6) in the fumaric acid molecule. If the break occurs at *a*, dextro tartaric acid is produced, while the break occurring at *b* would produce levo tartaric acid. The chances of the break being even for *a* or *b*, the result of the oxidation is the formation of equal amounts of dextro and levo tartaric acids; that is, the racemic mixture is produced. Here the models held in the hand and the tetrahedra separated along the edge, keeping one corner or solid angle in contact makes the matter clear to the class.

In the case of maleic acid, no matter whether the break occurs at *a* or *b*, the upper tetrahedron is a mirror image of the lower, which condition represents meso tartaric acid which is inactive toward polarized light and cannot be resolved into the dextro and levo forms by the usual methods.

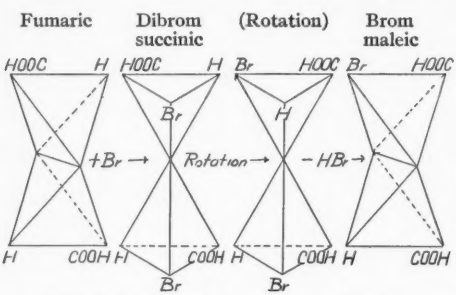
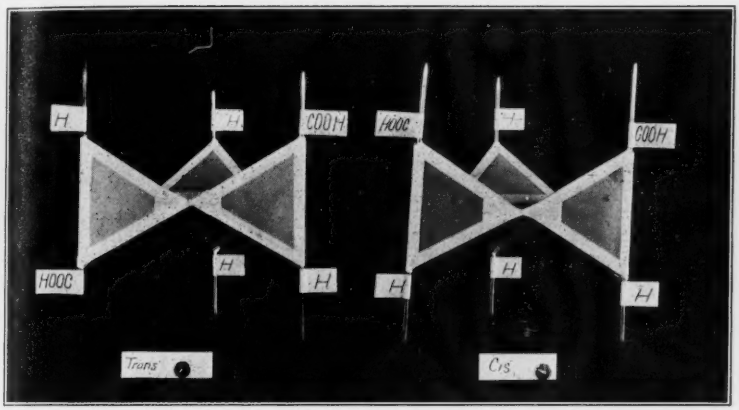


FIGURE 9.—CONVENTIONAL LINE DRAWINGS SHOWING THE TRANSFORMATION OF FUMARIC TO BROM MALEIC ACID

When maleic acid is brominated, it makes no difference at which end the double bond is broken, a dibrom succinic acid is formed which may be called isodibrom succinic acid. If hydrobromic acid be now removed from isodibrom succinic acid, this



MODELS SHOWING THE *Cis* AND *Trans* FORMS OF THE TWO DICARBOXYLIC ACIDS DERIVED FROM CYCLO PROPANE

removal will involve a rotation of one of the tetrahedra to bring a bromine atom over a hydrogen atom, the elimination of the hydrobromic acid giving rise to doubly bonded carbon atoms. To the representation of such a change the tetrahedra models lend themselves particularly well as shown by the models of Figure 8 (page 2909). Replacing the bromine with hydrogen produces fumaric acid, hence a transformation of maleic acid to fumaric acid has been made.

When fumaric acid is treated with bromine, no matter where the double bond is broken, a dibrom succinic acid is produced which is not identical with the corresponding compound formed when maleic acid is brominated. Call it dibrom succinic acid. When dibrom succinic acid has hydrobromic acid removed, a similar rotation as with isodibrom succinic acid must precede the elimination of hydrobromic acid and results in the formation of brom maleic acid.

The spacial difference between the *cis* and *trans* forms, for instance, of cyclopropane dicarboxylic acids, is well shown by the tetrahedra. Starting with 1, 3, dibrom propane, cyclo propane may be prepared:

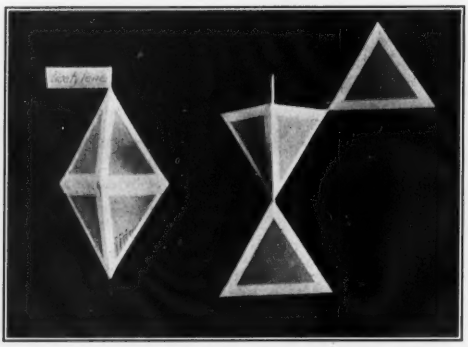
$$CH_2\begin{matrix}CH_2Br\\CH_2Br\end{matrix} + 2\,Na = CH_2\begin{matrix}CH_2\\|\\CH_2\end{matrix} + 2\,NaBr$$

Cyclo propane

In the same way that the double bond prevents the rotation of the tetrahedra, so tying up the ends in the formation of the polymethylenes likewise prevents free rotation. From cyclo propane two dicarboxylic acids may be derived, differentiated by the prefixes *cis* and *trans*. The spacial

differences and rigidity of structure are at once apparent from the tetrahedra models.

The strain theory is readily shown by the tetrahedra models. The model on the right in the photograph below may be taken to represent malonic acid which does not yield a true anhydride. To eliminate water would draw the free ends together which would put the molecule under too great a strain. The next acid, succinic acid, containing four carbon atoms forms an anhydride; the strain produced in tying up the ends is much lessened.



MODEL OF ACETYLENE SHOWING REPRESENTATION OF TRIPLY BOUND CARBON ATOMS, ALSO MALONIC ACID

Singly bonded carbon atoms are represented by joining the tetrahedra, solid angle to solid angle; doubly bonded carbon atoms are represented by the tetrahedra having an edge in common, while the triple bond is represented by a plane in common. Such is pictured in the last figure by acetylene.

In the presentation of this topic the author has used line drawings freely. However, in presenting the subject to the class, the use of tetrahedra makes these line drawings unnecessary and the instructor is free to devote his entire attention to the demonstration with a consequent gain in time and clearness of presentation.

Literature Cited

(*1*) For these relationships see PORTER, "The Carbon Compounds," revised edition, Ginn and Co., Boston, Mass., **1926**, pp. 130–6.

Speed of Super-Sound Waves Tells Squeezability of Chemicals. Measurements of the speed of ultra-sound waves, vibrating 400,000 times a second, twenty times as fast as the shrillest audible sound, in various solutions of chemicals were described at the Atlanta Meeting of the A. C. S. by three Johns Hopkins University chemists.

Speaking before the section on physical and inorganic chemistry, Drs. E. B. Freyer, J. C. Hubbard, and D. H. Andrews told of their work with the sonic interferometer. From such measurements can be determined the compressibility, or "squeezability" of the liquid. The chemicals tested were solutions of chlorides, bromides, and iodides of potassium and sodium, including common salt.—*Science Service*

MAKING LABORATORY WORK IN GENERAL CHEMISTRY EFFECTIVE

R. K. CARLETON, SHURTLEFF COLLEGE, ALTON, ILLINOIS

There have appeared in the columns of the JOURNAL OF CHEMICAL EDUCATION, from time to time, various articles lamenting the pitiably small accomplishments of laboratory work in general chemistry courses, particularly those given in the smaller colleges. It seems to be the almost universal consensus of opinion that the methods in use today do not secure the most efficient work on the part of either student or instructor. While a good deal of attention has been paid to developing the teaching in the classroom, the methods of conducting laboratory work have remained pretty much the same. Students are usually requested to supply themselves with a "suitable notebook" at the beginning of the college year, which they then proceed to fill with descriptions of experiments performed and which mean very little to any of the students unless they are deeply interested in the study of chemistry.

An article recently printed in THIS JOURNAL (*1*) brings out a number of points that warrant further discussion. Dr. Long is to be complimented for breaking away from the time-honored procedure of simply keeping a notebook.

If students are listless and unconcerned about the kind of work they do, isn't it true that we are inclined to place the burden of blame on them without searching farther for the real cause? No doubt there are certain conditions that are responsible for poor laboratory work on the part of first-year chemistry students. A student who has had a year of the subject in high school often feels that if he takes a year of general chemistry in college, he is simply repeating something with which he is already familiar, so "why study"? "Or why work either"? Then, too, the laboratory classes are usually small and the spirit of competition is not likely to be as keen as in larger units. Furthermore, a student does not get much of a "kick" out of doing a large number of experiments and writing them up in a notebook which he knows will be looked at infrequently. After he has performed the first half dozen experiments and has recorded them, his enthusiasm dies and the keeping of a notebook throughout the remainder of the year becomes pretty much of a mechanical process. Only those "good" students who are vitally interested in the subject will rise above that condition.

More deep-seated, however, than any of the aforementioned conditions is a lack of a sense of responsibility, characteristic of the majority of pupils entering college direct from high school. This is not to be wondered at as young pupils have had little experience that would tend to make them realize the necessity of assuming responsibility. Then, too, there is very little in the high-school course which requires students to develop this sense to any great degree. There is little doubt if a student hastens the

process of weighing by picking up analytical weights with his fingers instead of with tweezers, or carelessly spills acid on a desk, or needlessly breaks apparatus, it is because he knows the institution pays the bills, and consequently gives little thought to such seeming trifles. Students can be trained, however, within a period of one year to feel some responsibility in the matter of laboratory work.

In an attempt to free the laboratory work in first-year chemistry at Shurtleff College from some of these difficulties, a method was developed three years ago which has proved most satisfactory. At the opening of the college year in September, each student obtains from the College Book Store an experiment report pad, devised especially for chemistry work. These pads contain fifty lined sheets, the size of typing paper, perforated at the top so they can be torn out and showing the exact form in which an experiment should be written. Space is provided for a sketch of the apparatus used. At the lower right-hand corner of each sheet is a space for the instructor's signature and also for the word "accepted" to be stamped. When a student has performed an experiment he writes it up on one of these sheets in the laboratory, signs it, and deposits it in a locked box at one end of the laboratory. At the close of that period, the instructor removes all the papers that have been deposited and corrects them, stamping those that are satisfactory and placing them in an open box in the hall outside the laboratory where the students may secure them at their leisure. Those papers that are accepted are kept by each individual student in a folder until after the end of the semester. Those that are not correctly written, must be repeated, rewritten, and handed in again. Only those experiments that are accepted give the student credit for laboratory work. In this way, the responsibility for doing the experiment correctly and reporting it satisfactorily, as well as keeping the sheets after they have been corrected rests entirely with the student. At the end of the semester the number of "accepted" experiment sheets in each folder is determined and credit for laboratory work given each student on that basis as well as on laboratory manipulation and technic.

The use of this system has shown that a sense of responsibility can be created among first-year students that cannot be accomplished with the ordinary notebook. There is no trouble in maintaining a student's enthusiasm for the work throughout the year. Furthermore, any mistakes appearing in the writeup of an experiment can be checked immediately after the experiment has been performed and while the work is fresh in the mind of the student. There is a certain value in training a pupil to report laboratory work in an acceptable form. Certain it is that when one enters industrial chemistry, one will sooner or later have to write a report of one kind or another. Moreover, the year of general chemistry ought to be preparatory to further work in qualitative and quantitative analysis.

These latter courses cannot be properly taught without an accurate report being kept of the analyses performed in the laboratory. Where will a student be trained to report laboratory procedures accurately and carefully, if not in the general chemistry course?

Literature Cited

(1) LONG, H. J., "Tradition versus Effectiveness," J. CHEM. EDUC., 7, 1642–4 (July, 1930).

Pumice Manufacture in the Rosebud. Everybody can keep clean now. Down in Tripp County is being manufactured a new powdered soap, the base of which is pumice or volcanic ash. The source of supply is from one of the pits near Winner, which is thought to be many thousand yards square. There are other pits of pumice of equal size in that section which can be depended for future supplies. It is estimated that there are several million tons in various pits in S. Dakota.

Pumice is a cellular, glassy, volcanic lava, usually rhyolitic in composition. Its cellular structure, so geologists tell us, is due to the expansion of steam and gases in the melted lava during cooling.

Pumicite or volcanic ash is a fine powder or dust made up of small but sharp and angular grains of volcanic glass, similar in composition to pumice. It is formed by volcanic eruption throwing out dust in great clouds. When the dust settles, it is often hundreds of miles away from the source, and forms pumicite beds. It varies in color from white to lightly grey.

Analysis by the State School of Mines of Rapid City of this substance shows:

Silica	SiO_2	71.76%	Calcium Oxide	CaO	1.62%
Iron Oxide	Fe_2O_3	0.40	Magnesium Oxide	MgO	0.70
Aluminum Oxide	Al_2O_3	12.44	Potassium Oxide	K_2O	6.12
Manganese Oxide	MnO	0.11	Sodium Oxide	Na_2O	2.76

Loss on Ignition 4.14; total 100.00%.

After mining this pumice, it is carefully prepared and made into a powder as fine as flour and there is mixed with the powder a certain per cent of material to correctly condition the water. There is also a soap stock added; this soap stock is built for the company out of the very highest grade of imported palm and olive oils. Those oils are scientifically prepared under laboratory control by one of the largest soap companies in the world.

When this soap is completed and ready for the consumer, it is absolutely dry, having been baked in a brick oven, size $3\ ^1/_2 \times 16$ feet, which is for drying and purifying as well as sterilizing purposes.

Pumice is valuable as an abrasive; in silver plating and by lithographers for polishing various metals, such as copper and silver, before plating; for rubbing down wood and metal surfaces and paint and varnish finishes by manufacturers of furniture, pianos, phonographs and other musical instruments, automobile bodies; in the cutlery manufacture, for surgical instruments and other fine tools; by metal spinners; for cleaning and polishing stone and glass. A small amount of fine lump pumice is used as a toilet article, for removing cuticle, stains, etc.

In California and Japan crushed block pumice is used as a light-weight concrete aggregate. It is thought to be especially valuable for its wearing qualities. Investigation of this might prove of untold value.—FRANK D. KRIEBS, *Sec'y of Agriculture, Pierre, S. Dakota*

VISUAL AIDS IN CHEMICAL EDUCATION*

IV. Films Available for Use in Chemistry Classes

The Committee on Visual Aids in Chemical Education of the American Chemical Society has prepared the following list of films on subjects closely related to chemistry. This list is not long and is far from inclusive of all films which might be classed under some phase of chemistry. However, the committee has attempted in its first report to list those subjects which would interest the larger number of chemistry teachers. All distributors have been given an opportunity to check and correct information regarding films. The list is, therefore, as correct as it is possible to make it up to November 1, 1930.

Explanation of the subject matter of films has been omitted, but can be obtained by writing to the distributor. Many of these films are produced by industrial companies, but are not necessarily distributed by them. In some cases, industrial firms (*e. g.*, the E. I. du Pont de Nemours and Company, Inc.) have films distributed through several agencies, many of them the visual instruction departments of state universities. These universities and local agencies have not been listed as distributors, but a letter to the distributor listed here will bring the name of the local agency.

The majority of the films in this list are free to the exhibitor, with the understanding that express is to be paid by the user on films to and from the distributing point. One of the greatest sources of annoyance to the distributors is the failure of exhibitors to return the films on scheduled time. This often works a hardship on the next person scheduled to use the film and results in very unsatisfactory service. Exhibitors, therefore, will find themselves very welcome to use the films if they will show them on scheduled time and return them immediately after using. Another favor the user can show the distributor is to return the films without rewinding. Films are usually inspected by the distributor each time they return to him and should, therefore, come to him in the manner which is of most convenience. Chemistry teachers will also find much more satisfaction in the service if care is taken in the handling of the film while in use. The operator should be taught the correct way to make a neat patch and should be provided with a proper film cement.

In addition to the films listed below, The Bray Pictures Corporation (list number 8) has, for sale only, films on the following subjects: Peculiarities of the Air, The Air Pressure in Which We Live, American Matchmaking, An American Vesuvius (Oil), Asphalt, Black Sunlight (Coal), Making Bricks, From Candles to Electricity, How Candy Is Made, Carborundum, Chemical Inspirations, The Chemist Makes War, Spectacular Experiments in Crystallization, Coal, What Is Coal, Coal Mining, Dew-

* This is the fourth of a series of articles from the Committee of the Division of Chemical Education of the A. C. S. on Visual Aids in Chemical Education. See J. CHEM. EDUC., 7, 828–33, 1113–4, 1341–8 (1930).

fall, Nature's Jewels, The Eighth Wonder (Asphalt), Felt Hat Making, Gold Mining in Alaska, Hard as Diamonds (Carborundum), Experiments in the Conduction of Heat, Natural and Made-to-Order Ice, Tapping the Maples, Mining for Beauty (Talcum), A Newspaper in the Making, Romance of Oil, California Oil Gardens, Controlling an Oil Gusher, Converting Wood into Paper, Perilous Occupations, Talcum, How the Telephone Talks, The Destructive Power of T. N. T., Turning Kansas Upside Down (Coal), Turning Waste into Dollars (Turpentine), Wireless Telephony. These films may be purchased in either 16 mm. or 35 mm. safety stock.

The committee has been furnished with several sources of film material, which upon investigation were found to have no films on chemical subjects available. In the accompanying list of distributors we have so indicated this fact so that users may know that these sources were canvassed.

In the next issue of the JOURNAL OF CHEMICAL EDUCATION information will be given regarding sources of slides, film-slides, and illustrative material in chemistry which have been collected by the committee.

Although the committee does not claim that the list of films given here is absolutely correct in every detail, every effort has been made to make it so. The committee wishes to thank the producers and distributors of the films listed herein for the fine coöperation they have given, and also express a hope that users of films will report at any time to the committee chairman additions or corrections which they find should be made to this list.

Film Distributors and Addresses

The distributors marked with an asterisk do not have chemistry films for distribution.*

1. ACME EDUCATIONAL FILM SERVICE, 1132–1136 W. Austin Avenue, Chicago, Ill.
2. AIR REDUCTION SALES CORPORATION, 342 Madison Avenue, New York City.
3. AMERICAN ROLLING MILL CO., Middletown, Ohio.
4. AMERICAN TELEPHONE AND TELEGRAPH CO., 195 Broadway, New York City.
5. AMERICAN STEEL AND WIRE CO., 208 South LaSalle Street, Chicago, Ill.

*6. ATLAS EDUCATIONAL FILM CO. (*producers only*), 5 North Wabash Avenue, Chicago, Ill.

7. BAUSCH & LOMB CO., 629 St. Paul Street, Rochester, N. Y.
8. BRAY PICTURES CORP., Department of Education and Public Service, 729 Seventh Avenue, New York City.
9. BUREAU OF COMMERCIAL ECONOMICS, 1108–10 16th Street, N. W., Washington, D. C.
10. BUREAU OF MINES, 4800 Forbes Street, Pittsburgh, Pa
11. BROWN, H. S., 806 S. Wabash Avenue, Chicago, Ill.
13. CARTER CINEMA PRODUCING CORP., 551 Fifth Avenue, New York City.
15. CHURCH AND SCHOOL FILM EXCHANGE, 317–8 Polk Bldg., Des Moines, Ia.
16. DE FRENES AND CO., 60 N. State St., Wilkes Barre, Pa.

*17. Q. R. S.—DE VRY CORP., 333 N. Michigan Blvd., Chicago, Ill.
18. DAVIS, H. O., 106 S. Hudson St., Oklahoma City, Okla.
19. E. I. DU PONT DE NEMOURS AND CO., INC., Wilmington, Del.
20. EASTMAN TEACHING FILMS, INC. (*sale only*), 343 State Street, Rochester, N. Y.
21. EDITED PICTURES SYSTEM, INC. (*rent only*), 130 W. 46th Street, New York City.
22. FILM CLASSIC EXCHANGE, 265 Franklin Street, Buffalo, N. Y.
24. FRANCIS P. GARVAN CHAIR OF CHEMICAL EDUCATION, The Johns Hopkins University, Baltimore, Md.
25. GENERAL ELECTRIC CO., 1 River Road, Schenectady, N. Y.
26. GOODYEAR TIRE AND RUBBER CO., Akron, Ohio.
27. GRINNELL CO., INC., 277 W. Exchange Street, Providence, R. I.
28. HERCULES POWDER CO., Wilmington, Del.
29. INDIANA UNIVERSITY, Bloomington, Ind.
30. INTERNATIONAL HARVESTER CO., 606 S. Michigan Ave., Chicago, Ill.
31. IOWA STATE COLLEGE, Visual Instruction Service, Ames, Ia.
32. NATIONAL MOTION PICTURE CO., Indianapolis, Ind.
*33. OHIO STATE DEPARTMENT OF EDUCATION, B. A. Aughinbaugh, 68 E. Paterson Avenue, Columbus, Ohio.
34. PORTLAND CEMENT ASSOCIATION, 33 West Grand Avenue, Chicago, Ill.
35. ROTHACKER FILM CORPORATION, 113–115 W. Austin Avenue, Chicago, Ill.
36. ROWLAND ROGERS PRODUCTIONS, 74 Sherman Street at Harris Avenue, Long Island, N. Y.
37. SOCIETY OF VISUAL EDUCATION, 327 LaSalle Street, Chicago, Ill.
*38. SPENCER LENS CO., 19 Doat Street, Buffalo, N. Y.
*39. STANDARD MOTION PICTURES CO., Film Building, Cleveland, Ohio.
40. SWIFT AND CO., Union Stockyards, Chicago, Ill.
*41. YALE UNIVERSITY PRESS FILM SERVICE, INC., 386 Fourth Avenue, New York City.
42. MOTION PICTURE BUREAU OF THE NATIONAL COUNCIL OF THE Y. M. C. A., 120 W. 41st Street, New York City; 300 W. Adams Bldg., Chicago, Ill.
43. UNIVERSITY OF WISCONSIN, Madison, Wis.
*45. WESTINGHOUSE ELECTRIC CO., East Pittsburgh, Pa.
46. WHOLESALE FILMS, 42 Melrose St., Boston, Mass.
*47. W. M. WELCH MANUFACTURING CO., 1515 Sedgwick St., Chicago, Ill.
48. NATIONAL CASH REGISTER CO., Main and K Streets, Dayton, O.
49. J. ALEXANDER LEGGETT CO., 2 West 46th Street, New York City.
50. AMERICAN SUGAR REFINING CO., 117 Wall Street, New York City.
51. IDEAL PICTURES CORPORATION, 26 E. 8th Street, Chicago, Ill.
52. EDISON STORAGE BATTERY, Orange, N. J.
53. U. S. DEPARTMENT OF AGRICULTURE, Washington, D. C.
54. SPIRO FILM CORPORATION, 161–179 Harris Avenue, Long Island City, N. Y.
56. CHILEAN NITRATE OF SODA EDUCATIONAL BUREAU, 57 William Street, New York City.
57. FRUIT OF THE LOOM MILLS, INC., 40 Worth Street, New York City.
58. VISUGRAPHIC PICTURES, INC., 247 Park Avenue, New York City.
59. PICTORIAL CLUBS, INC., 808 S. Wabash Street, Chicago, Ill.
60. UFA FILMS, INC., 1540 Broadway, New York City.
61. C. L. VENARD, 702 S. Adams Street, Peoria, Ill.

62. THE CORTICELLI SILK CO., 136 Madison Avenue, New York City.
63. BELDING HEMINGWAY CO., 180 Madison Avenue, New York City.
64. CANADIAN GOVERNMENT MOTION PICTURE BUREAU, Ottawa, Canada.
65. CHICAGO FILM LABORATORY, INC., 666 Lake Shore Drive, Chicago, Ill.
66. CLAY PRODUCTS ASSOCIATION, Chicago, Ill.
67. AMERICAN DRY MILK INSTITUTE, Chicago, Ill.
68. THE BALL BROTHERS, Muncie, Ind.
69. INTERSTATE IRON AND STEEL CO., Chicago, Ill.
70. GAS PRODUCTS ASSOCIATION, Chicago, Ill.
71. LINK BELT CO., Chicago, Ill.

Films Classified According to Subjects

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16 35*	*Distributors Free (Unless otherwise designated)*
Abrasives				
Age of Speed	4	S	35	42
Jewels of Industry	2	S	16	35
			35	35, 42
Manufacture of Abrasives (Carborundum Aloxite)	3	S	Both	10
Story of Abrasives (Carborundum Aloxite)	4	S	Both	1
Alcohol				
Chemical Ethyl Alcohol	2	S	Both	16, 42
Aluminum				
Chemical Effects of Electricity	1	S	16	(20 Sale)
Magic Gems—Prisma	1		35	22
Making Wear-Ever Cooking Utensils	1	S	Both	42
Asbestos				
Asbestos for 1000 Years	1	I	35	51
Story of Asbestos	4	S	35	1
Story of Asbestos	1	S	Both	10
Atmosphere				
Air	1	S	16	(42 Rent)
			35	35 (42 Rent)
Atmospheric Pressure	1	S	16	(20 Sale)
Compressed Air	1	S	16	(20 Sale)
Liquid Air	1	S	Both	25, 43
Liquid and Compressed Air	1	I	35	(21 Rent)
Science at Home	1	S	35	54(21 Rent)
Bakelite				
Story of Bakelite	2	S	35	29, 35, 42
Batteries				
Application of Chemistry (Manufacture of Storage Battery)	1		35	43
Making an Edison Storage Battery	2	S	35	29

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16 35*	*Distributors Free (Unless otherwise designated)*
Portable Electricity	2	S	16	42, 49
			35	42, 49, 52 (8 Sale)
Story of a Storage Battery	2	S	Both	10
Story of a Storage Battery	1	S	35	29
Calcium				
Enamelware	2	S	35	42
From Mine to Wall	2	S	35	30
Limestone to Marble	1	S	16	(20 Sale)
10 Years of Limestone	1		35	61
Carbon				
Acres of Diamonds	1	S		42
Anthracite Coal	1	S	16	(20 Sale)
	1	S	Both	25, 29, 43
A Rush for Diamonds	1	S	Both	60
Behind the Pyramids	3	S	35	42
Bituminous Coal	1	S	16	(20 Sale)
	1	S	Both	25, 29, 43
Buried Sunshine	2	S	Both	42
Burning Questions	2	S	Both	42
Carbon Monoxide, The Unseen Danger	1	S	Both	10, 31
Coal Mining (Surface)	1	S	35	(43 Rent)
Fertilizer from Coal	3	S	35	35
How a Lead Pencil Is Made	1	I	35	49
Industrious Diamonds	1	S	35	42
Modern Coal Mining	3		35	1
Romance of Anthracite	1	I	35	(21 Rent)
Saving Coal at Home	1	S	35	10
Story of Coal	3		35	1
Strip Mining	1	S	Both	35
Wonders of Anthracite	2	S	35	42
	2 or 4	S	Both	16
Cement				
A Concrete Example	2	S	35	42
Cementing the Centuries	2	S	35	29, 31, 42
Concrete Facts	2		Both	10
Manufacture of Universal Atlas Portland Cement	2	S	35	49
Story of Portland Cement	1	S	Both	16, 29, 34, 42, 65
Clay Products				
Craftsmanship of Stucco Texture	1	S	35	65
Fire-Clay Refractories	3	S	Both	10
From Clay to Pavement	1		35	1, 53
Making Lenox Pottery	1	S	35	31, 42 (18 Rent)
Making Pottery	1	I	35	48
Manufacture and Use of Face Brick	1	S	16	42
			35	42, 65
Pottery	1	S	35	29

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16*	*35*	*Distributors Free (Unless otherwise designated)*
Romance of Clay	1			35	66
Sand and Clay—Rock Soil Cycle	1	S		16	(20 Sale)
Tableware	1	S		16	(20 Sale)
Terra Cotta	1	S		Both	42
The Lenox Pottery	1	S		Both	49
The Potters Wheel	1			Both	25
The Pottery Maker	1	S		Both	(31 Rent)
Copper					
Chemical Effects of Electricity	1	S		16	(20 Sale)
Copper Mining and Smelting	1	S		35	42
Copper Mining at Anaconda, Mont.	12	S		35	1
From Mine to Consumer	2	S		Both	42
Long Drawn Out (Wire)	1	S		35	42
Mining and Smelting of Copper	1	S		16	(20 Sale)
Mining at Calumet and Hecla	2			35	1
Refining and Manufacturing of Copper	2	S		35	42
Story of Copper Mining —5 Reels Milling —2 Reels Smelting—1 Reel Refining—2 Reels	10	S		35	10, 35
Crop Production					
Alfalfa	1	S		Both	30
Corn, Greatest of Our Farm Crops	2	S		Both	56
Fertilizing Wheat	1	S		Both	56
Producing Profitable Corn in the South	1	S		Both	56
Producing Profitable Cotton	2	S		Both	56
Explosives					
Blasting the Water Highway of America	1	S		35	19
Building New York's Newest Subway	1	S		Both	19
Driving the Cascade Tunnel	1	S		Both	19
Dynamite	6			35	19
Dynamite, Concentrated Power	1	S		35	53
Dynamite in Quarry Work	1	S		35	19
Dynamite the Master Lumberjack	1	S		35	19
Explosives—Dusts	2	S		35	53
From Forest to Farms	1	S		35	19
Green Valley	2	S		Both	19, 61
Hydro-Electric Power Production in the New South	2	S		Both	19
Letting Dynamite Do It	1	S		Both	19, 31
Manufacturing and Testing of Smokeless Powder	4	S		Both	19
Manufacture of Progressive Burning of Smokeless Powder	1			35	19
Manufacture of Smokeless Powder	1			35	19
Modern Quarry Blasting	1	S		35	29
Rubbing the New Aladdin's Lamp	1	S		35	28, 42

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16*	*35*	*Distributors Free (Unless otherwise designated)*
Story of Dynamite	2	S		35	10, 19
The Legacy	2	S		Both	19, 31, 61
The Modern Hercules	1	S		35	28, 29, 42
Foods					
A B C of Food	1	I		35	(21 Rent)
Across Seven Seas (Tapioca)	1	S		Both	49
Better Bread	1			Both	67
Better Milk	1	I		Both	(21 Rent)
Chemical Composition and Food Value of Whole Wheat	2			35	36
Corn	1	S		16	(20 Sale)
Crystals of Commerce	1	S		Both	35
Familiar Foods from Foreign Lands	1	S		35	(22 Rent)
Filling the World's Cereal Bowl	2	S		35	35
Food	1	S		35	(21 Rent) (13 Rent)
From Wheat to Bread	1	S		16	(20 Sale)
Home Builders	3	S		35	30, 42, 65
Keeping Out Bad Food	1	I		35	48, 53
Land of Cherries	1	S		35	29, 30, 31, 42, 43, 65
Leavener of Life	1	S		35	35
Leavening	3	S		35	29
Making Malted Milk	1			35	43
Making Maple Sugar	1	S		Both	(21 Rent)
Meat Packing	1	S		16	(20 Sale)
Milk	1	S		35	42
Milk as Food	1	S		35	(21 Rent)
Milk, Nature's Perfect Food	1	S		35	30 (21 Rent)
Milk, the Great White Way to Health	2	S		35	16 (13 Rent) (13 Sale)
Once Over and It's All Over	2	S		35	30, 65
Peanuts	1	S		16	(20 Sale)
Power Behind the Orange	1	S		35	30, 29, 31, 42, 43, 65
Power Farming in the Northwest	1	S		35	30, 65
Power Farming in the South	3	S		35	30, 65
Staff of Life	1	I		35	(21 Rent)
Sunshine	2 or 1	S		Both	35
The Horseless Farm	2	S		35	29, 30, 42, 65
Uncovering Earth's Riches	1	S		35	29, 30, 65
Wisconsin Dairies	1	S		16	(20 Sale)
General Chemistry					
Asphalt Blocks	1	S		Both	42
Chemical Effects of Electricity	1	S		16	(20 Sale)
Chemistry	1			35	43
Energy from Sunlight	1	S		16	(20 Sale)
Experiments in Chemistry	1	I		35	48
Fire and Heat	1	S		16	(21 Rent)
Fire Prevention (Oil—Volatile Liquids)	4			35	1
Fire Prevention	1	S		16	(20 Sale)
Fire Protection	1	S		16	(20 Sale)
Fire Safety	1	S		16	(20 Sale)

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16 35*	*Distributors Free (Unless otherwise designated)*
The Grinnell Sprinkler Head	1		35	27
Making of Chewing Gum	1	I	35	48
Making Thermometers	1	S	35	29, 36
Mysterious Forces	2	S	16	(21 Rent)
The Science of Bubbles	1	I	35	48 (18 Rent) (18 Sale)
Wheels of Progress or Development of Road Building	1	S	35	29, 34, 43
Glass				
American Bottles—Old and New	2	S	35	Owens Bottle Co.
Glass Blowing	2	S	16	(20 Sale)
Romance of Glass	1	S	16	68
			35	29, 42, 43, 68
Romance of Glass	1	I	35	51
Sand and Clay	1	S	16	(20 Sale)
The Magic Jar	1	S	Both	42, 68
Gold				
Acres of Diamonds and Miles of Gold	1/2	S	35	42
Dredge Gold Mining	1		35	1
Gold	1	S	16	(20 Sale)
Nuggets of Gold	1			(18 Rent)
Hydrocarbons				
Doings of Terp and Tine	2 or 1	S	35	28, 31, 42
Magic Flame	4	S	Both	70
Modern Oil Refining	1	S	35	31 (43 Rent)
Oil	1	I	35	51 (18 Rent)
Oil, the Wood Preserver	1	S	35	42
Oil Tydings	4	S	35	42
Petroleum Industry	1		35	(18 Rent)
Producing Crude Oil	1	S	16	(20 Sale)
Refining Crude Oil	1	S	16	(20 Sale)
Romance of Oil	1	I	35	(21 Rent)
Story of a Rotary Drilled Oil Well	2	S	35	10
Story of Gasoline	3	S	35	1, 10, 29
Story of Lubricating Oil	2	S	35	10
Story of Lubrication	1	S	35	10
Story of Natural Gas	4		35	1
Story of Petroleum	4 or 7	S	35	1, 29
Story of Petroleum	8	S	35	10
Story of Turpentine	1	S	35	29
Through Oil Fields of Mexico	3	S	Both	10
World Struggle for Oil	7	S	35	1, 29
Hydrogen				
Beyond the Microscope	1	S	16	25
			35	1, 29, 31, 43 (21 Rent)
Iron and Steel				
Arteries of Industry	4	S	35	42
Blue Center (Wire Cable)	3	S	Both	42

Subject — *Name of Film*	*No. Reels*	*Stock Saf.*	*Stock Inf.*	*16*	*35*	*Distributors Free (Unless otherwise designated)*
Continuous Process of Making Iron and Steel Sheets	4 or 2	S		Both		3
Iron and Steel	1	S		35		29
Iron and Steel	2		I	35		48
			S	35		31
Iron and Steel Industry	1			35		(18 Rent)
Iron Ore to Pig Iron	1	S		16		(20 Sale)
Laying of Electric Cable across San Francisco Bay	1			35		5
Making It Tough	3	S		Both		10
Making of American Wire Rope	2			35		5
Making of Steel	2	S		35		29, 30, 31, 42, 43, 65
Making of Steel and Wire	5			35		1
Making of Steel Pipe	4			35		1, 10
Manufacture of Paper Insulated Power Cables	3			35		5
Pig Iron to Steel	1	S		16		(20 Sale)
Rolling Steel by Electricity	2			35		1
Something New under the Sun	1	S		Both		25
Speeding Production with Carboloy	1	S		Both		58
Steel for Sheets and Tin Plates	4			35		1
Steel Industry	6	S		35		29
Story of Alloy Spring Steel	2	S		35		42
Story of Alloy Steel	4	S		35		1, 42, 69
Story of Heat Treatment of Steel	2	S		Both		10
Story of Ingot Iron	3	I		35		1
Story of Iron	5	S		35		10
Story of Steel	6	S		35		1, 42
Story of Steel	2	S		35		42
Story of Steel	5	S		Both		5
Story of Steel	6	S		Both		10
Mining and Metallurgy—2 Reels Rails, Rods, and Plates—1 Reel Wire Products —1 Reel Lap-Welded Pipe —1 Reel Sheets and Tin Plates —1 Reel						
Story of Steel and Wire Products	4			35		5
Story Your Ink Bottle Tells	2			35		1
Uses of Wire Rope	2			35		5
Lead						
Chemical Effects of Electricity	1	S		16		(20 Scale)
From Pigs to Paint	2	S		35		42
Lead	1	S		16		(20 Sale)
Story of Lead Mining and Milling	3	S		35		10
Story of Lead Smelting	2	S		35		10, 29
Leather						
American Glove Craft	3	S		Both		16
Manufacture						
A Day with the Tractor Builders	2	S		35		29, 30, 42, 65

Subject / Name of Film	No. Reels	Stock Saf. Inf.	16 35	Distributors Free (Unless otherwise designated)
Building Quality into Cream Separators	2	S	35	30, 42, 65
The Making of Twine	1	S	35	29, 30, 31, 42, 43, 65
Matches				
Fire Making	1	S	16	(20 Sale)
Liquid Fire	1	S	Both	(60 Rent)
Science in the Home	1	S	35	31
Story of a Lucifer Match	1	S	35	(21, 59 Rent)
Nickel				
Mining Nickel and Copper Ore	1	S	35	43
Monel Metal	2	S	Both	35
Nitrogen				
The Chilean Nitrate Industry	2	S	Both	56
Farm for Sale	1		35	61
Refrigeration	1	S	16	(20 Sale)
Silica Gel (Refrigeration)	3	S	Both	42
Oxygen				
Chemistry of Combustion	1	S	35	43 (22, 46, 59 Rent)
Conduction of Heat, Chemistry of Combustion	1	S	35	43
Explosive Dusts	1		35	1, 53
Fire Making	1	S	16	(20 Sale)
Magic Flame	4	S	Both	70
Oxygen Breathing Apparatus	1	S	35	10
Oxygen the Wonder Worker	2 or 4	S	35	2, 10, 42
Steam Power (Mechanical Stoker)	1	S	16	(20 Sale)
Stoker Combustion	2	S	35	43
Paints				
Lacquer and Pearls (Japanese Crafts)	1	S	Both	60
Paper				
A Day with the Sun	2	S	Both	42
Forest to Newsboy	1	I	35	48
From Trees to Tribunes	3	S	35	31, 42
From Tree to Newspaper	1	S	16	(20 Sale)
Miracle of Mulch Paper	1	S	Both	31, 58
Miracles of Mulch Paper	1	S	35	43
Modern Paper Making	4		16	16
Paper Making	1	S	35	29
The Voice of Business	3	S	35	42
Wall Paper the Beautiful	2	S	Both	42
World of Paper	2	S	35	25, 29
Rubber				
Conquering the Jungle	1	S	Both	26, 30
Romance of Rubber	2	S	16	35
			35	42, 35
Rubber	1	S	16	(20 Sale)

Subject / Name of Film	No. Reels	Stock Saf. Inf.	16 35	Distributors Free (Unless otherwise designated)
Rubber Industry	1	S	35	29
Rubber of Yesterday	1		35	1
Story of a Tire	1	S	Both	26
Story of Rubber	4		16	16
Where They Go Rubbering	1	I	35	31, 48
Salt				
Common Salt	1	S	16	(20 Sale)
Crossing the Great Salt Desert	1	S	35	43
Ocean Tears	1	I	35	48
Pillars of Salt	1	S	16	25
			35	29
Salt Mining	1	I	35	5
Silver				
Art of the Silversmith	1	S	Both	10
I See You Calling Me	1	S	35	4
Pictures by Wire	1	S	35	4
Silver	1	S	16	(20 Sale)
Silver: Heirlooms of Tomorrow	3	S	Both	10
Silverware (Plating)	1	I	35	48
Soap				
Science of Soap Bubbles	1		35	(59 Rent)
Soap	1	S	16	(20 Sale)
Sugar				
Beet and Cane Sugar	1	S	16	(20 Sale)
Beets from Seed to Sugar Bowl	1	S	35	53
Cane Sugar	2	S	Both	42
Cuba—The Island of Sugar	2	S	Both	25
Maple Sirup and Sugar	1	S	16	(20 Sale)
Sugar Cane and Cane Sugar	1	S	35	1, 53
Sugar Industry	1	I	35	51
	1	S	35	29
Sugar Refining	2	S	35	50
The Sugar Trail—"Beets"	1	S	Both	1, 25
Sulfur				
Experiments in Sulfur	1		35	(59 Rent)
Story of Sulfur	2	S	Both	1, 10, 29, 31, 35 (46 Rent)
Textiles				
Civilizations Fabric (Cotton)	2	S	Both	57
Cotton Growing	1	S	16	(20 Sale)
Cotton Goods	1	S	16	(20 Sale)
From Cocoon to Spool	1	S	16	62
			35	42, 62
From Flax to Linens	1	S	16	(20 Sale)
Golden Fleece	1	S	Both	60
Making of Twine	1	S	35	42

Subject *Name of Film*	*No. Reels*	*Stock Saf. Inf.*	*16*	*35*	*Distributors Free (Unless otherwise designated)*
Philippine Islands (Hemp)	1	S	16		(20 Sale)
Romance of Rayon	2	S	35		29, 31, 42
Romance of Silk	1	S	35		63
Silk	1	S	16		(20 Sale)
Silken Cocoons	1	S	Both		60
Story of Chase Velmo	3	S	Both		42
Story of Cotton	2	S	Both		42
Trip through Filmland	2	S	Both		16
Valves					
Open and Shut	3	S	Both		10
Water					
A Modern Sewage Treatment Plant	3			35	71
	1			35	29, 34
Chemical Inspirations (Crystallization)	1	S		35	43
Conowingo (Construction of Hydro-Electric Plant)	2	S	Both		42
Frazil Ice	1	S		35	64
Irrigation	1	S	16		(20 Sale)
				35	29
Mysteries of Snow and Ice	1	I		35	48
		S		35	(43 Rent) (8 Sale)
Nature's Frozen Credits	3	S		35	42
New York's Water Supply	1	S	16		(20 Sale)
Purifying Water	1	S	16		(20 Sale)
Sewage Disposal	1	S	16		(20 Sale)
Water	1	S	Both		(42 Rent)
Water Cycle	1	S	16		(20 Sale)
Water Power	1	S	16		(20 Sale)
Water Power	2	S		35	10, 31
Waste Disposal in Cities	1	I		35	31
Wonderful Water (Natural Colors)	1	I		35	(22 Rent)
Work of Underground Water	1	S	16		(21 Rent)
Zinc					
Laying the World's Fastest Ocean Cable (Permalloy)	2	S		35	42
Manufacturing of Zinc Oxide	1			35	1
Story of Zinc Mining	1	S		35	43
Zinc Mining, Milling, and Smelting	4			35	1
Theory					
Beyond the Microscope	1	S	16		25
				35	1, 29, 31, 43
Chemical Effects of Electricity	1	S	16		(20 Sale)
Electro Chemistry	1	S	16		20
Secrets of Chemistry	1	I		35	(22 Rent)
Sound Pictures					
Cosmic Ray by R. A. Millikan	6	S		35	24

THE CINCINNATI MEETING

Report of the Secretary of the Division of Chemical Education

General

The 80th meeting of the American Chemical Society extended from Monday, September 8th, to Friday, September 12th, with the Cincinnati Local Section playing a most successful rôle as host to nearly 1700 chemists and their friends.

The activities of the Division of Chemical Education included one business meeting of the Division, two of its Executive Committee, and one of the Senate. (*Cf.* pages 2944, 2929, 2933 for the respective minutes.) Four sessions were devoted to the reading and discussion of eighteen papers, the titles of which were announced in the September issue of the JOURNAL OF CHEMICAL EDUCATION (pages 2177–8). Attendance reached a total of 200 at the Symposium on "The Qualifications of Chemistry Teachers." The papers themselves have been submitted to the Editor-in-Chief for publication.

Wednesday noon, through the courtesy of MR. WM. W. BUFFUM, of The Chemical Foundation, Inc., the Division entertained at luncheon a number of teachers of high-school chemistry in the Cincinnati area. The total attendance at the luncheon was 97. At the close of the luncheon, CHAIRMAN SWAN introduced the following speakers: DEAN L. H. PECKSTEIN, of the School of Education of the University of Cincinnati; PROFESSOR NEIL E. GORDON, *editor* of the JOURNAL OF CHEMICAL EDUCATION; PROFESSOR PAULINE BEERY MACK, *editor* of *The Chemistry Leaflet;* and DR. HARRISON E. HOWE, *editor* of *Industrial and Engineering Chemistry.*

Dean Peckstein drew attention to the individual limitations of the fields of education and chemistry. He said that since the latter deals with the facts of matter, while the former deals with the growth and development of man, we should recognize the human qualities in the teaching of chemistry. We should endeavor to present the subject in accordance with the laws of psychology and, above all, we should remember that we are engaged not only in training chemists but in developing men and women.

Dr. Gordon announced that the Prize Essay Contest will be continued for the eighth time this year, explained the new rules that will be in operation, and thanked the teachers for the coöperation that has improved the contest from year to year.

At the conclusion of Dr. Gordon's talk, Dr. E. E. Reid, of The Johns Hopkins University, proposed that the meeting send to Mr. Garvan a telegram of greeting and thanks, which proposal was unanimously adopted. (The telegram was dispatched by the Secretary.)

Mrs. Mack (Pauline G. Beery) spoke briefly of the work which *The Chemistry Leaflet* is trying to do as Student Supplement of the JOURNAL OF CHEMICAL EDUCATION, lauding Francis P. Garvan as the patron saint of chemical education who had relieved the publication of its financial worries, and stating that it was a real joy to be the *Leaflet's* editor with Dr. Neil Gordon as the inspiring editor-in-chief of the Division of Chemical Education, and Mr. Wm. W. Buffum as the very excellent business manager.

Dr. Howe was introduced as the first Chairman of the A. C. S. Committee on the Prize Essay Contest, as well as a hardy perennial in the cause of chemical education. He said that, notwithstanding a man's personality and skill in teaching, he must know something of his subject if he or his scholars are to be a success. Dr. Howe emphasized the importance of popular interest in chemistry, and of nation-wide participation in the annual Prize Essay Contest. He paid fitting tribute to Mr. and Mrs. Francis P. Garvan, who inaugurated and have continuously supported the contest.

The meeting of the editors of the JOURNAL OF CHEMICAL EDUCATION and *The Chemistry Leaflet* Wednesday afternoon was followed by a dinner. The policies of the Divisional publications were informally discussed. The following were in attendance:

NEIL E. GORDON, *Editor-in-Chief;* PAULINE B. MACK, *Associate Editor;* WM. W. BUFFUM, *Business Manager;* L. C. NEWELL, W. SEGERBLOM, and ROSS A. BAKER, *Departmental Editors;* F. E. CLARK, A. J. CURRIER, F. B. DAINS, J. S. GUY, B. S. HOPKINS, T. R. LEIGH (representing A. P. BLACK), H. S. MOSELEY, A. M. PARDEE, L. E. PORTER, J. N. SWAN, and A. P. SY, *Contributing Editors.*

Minutes of the Meetings of the Executive Committee

8.00–12.00 A.M., September 8, and 8.30–11.45 A.M., September 9, 1930

Present: J. N. SWAN, *Chairman;* R. A. BAKER, *Secretary;* ROSALIE M. PARR, *Treasurer;* WILHELM SEGERBLOM and B. S. HOPKINS, *Past Chairmen;* NEIL E. GORDON, *Editor-in-Chief;* and by invitation, WM. W. BUFFUM, *Business Manager,* and E. J. MORGAN, *Local Secretary.*

REPORTS OF OFFICERS

1. **Chairman:** The Chairman reported upon committee appointments and changes in personnel, all of which have been or are soon to be listed in the JOURNAL OF CHEMICAL EDUCATION. The report was accepted.

2. **Secretary:** The Secretary reported that there are now 240 active and 301 associate members of the Division. He also reported upon (*a*) the letter ballot to the Senate subsequent to the Atlanta meeting (see page 2934); (*b*) the securing of over 100 back copies of the JOURNAL OF CHEMICAL EDUCATION; (*c*) preparations for the Cincinnati meeting; and, (*d*) tentative plans for the Indianapolis meeting in the spring of 1931. The report was accepted.

3. **Local Secretary:** The Local Secretary described his activities in (*a*) establishing contacts with high-school teachers in the Cincinnati area, (*b*) arranging for exhibits, and (*c*) housing students. The report was accepted.

4. **Treasurer:** The Treasurer presented a report showing receipts and expenditures from January 1 to August 1, 1930. The report was accepted and will be published in full at the end of the fiscal year.

5. **Editor-in-Chief:** The Editor reported that the work of his office is running satisfactorily, due largely to the fine coöperation of the contributing editors, and persons interested in the JOURNAL OF CHEMICAL EDUCATION in the way of securing outstanding articles from various parts of the country, and the very efficient office help in putting these articles into shape for publication. The office force has been reduced by one because of the elimination of the student section in the JOURNAL. The abstract section is causing some difficulty, and to eliminate this difficulty, the entire list of periodicals has been revised and the periodicals are being reassigned.

Upon the Editor's recommendation, it was voted to furnish authors of JOURNAL articles not more than 50 complimentary uncovered reprints, in place of 20 complete copies of the JOURNAL, as has been the custom, and to mail, with the compliments of the author, copies of the JOURNAL containing his article to persons whose names and addresses the author may supply.

6. **Business Manager:** The Business Manager reported upon the management of the JOURNAL and *Leaflet,* showing an expected and rapid rise in the number of subscribers to the latter. He again called attention to the seemingly unwarranted expense of securing temporary one-year subscriptions to the JOURNAL OF CHEMICAL EDUCATION. He presented an elaborate analysis of the subscription lists of the Division, which included (*1*) the complete list of group JOURNAL subscriptions classified by expiration months, (*2*) single subscriptions classified by states, as well as by expiration dates, (*3*) JOURNAL subscribers and non-subscribers among chemistry and science teachers classified by states, (*4*) classification of JOURNAL subscribers by professions, (*5*) number of subscribers to *The Chemistry Leaflet* by months from October, 1929, to July, 1930. As many of these tables as space permits appear on pages 2930–3.

SUBSCRIPTIONS TO THE JOURNAL OF CHEMICAL EDUCATION

State	Number as of August 31, 1929	Number as of August 30, 1930	Increase or Decrease
Alabama	60	40	−20
Arizona	28	35	7
Arkansas	52	45	−7
California	444	454	10
Colorado	77	86	9
Connecticut	121	124	3
Delaware	26	32	6
District of Columbia	71	60	−11
Florida	176	247	71
Georgia	82	57	−25
Idaho	24	18	−6
Illinois	688	687	−1
Indiana	167	161	−6
Iowa	121	161	40
Kansas	107	92	−15
Kentucky	103	96	−7
Louisiana	48	48	0
Maine	45	43	−2
Maryland	300	336	36
Massachusetts	285	276	−9
Michigan	231	216	−15
Minnesota	174	148	−26
Mississippi	47	88	41
Missouri	170	129	−41
Montana	51	44	−7
Nebraska	109	129	20
Nevada	12	8	−4
New Hampshire	31	33	2
New Jersey	248	255	7
New Mexico	14	15	1
New York	1036	1022	−14
North Carolina	77	53	−24
North Dakota	27	20	−7
Ohio	1728	1783	55
Oklahoma	62	73	11
Oregon	83	170	87
Pennsylvania	559	669	110
Rhode Island	50	46	−4
South Carolina	60	44	−16
South Dakota	68	106	38
Tennessee	76	63	−13
Texas	179	139	−40
Utah	40	37	−3
Vermont	24	21	−3
Virginia	117	120	3
Washington	129	125	−4
West Virginia	336	356	20
Wisconsin	179	165	−14
Wyoming	10	7	−3

Country	*Number as of August 31, 1929*	*Number as of August 30, 1930*	*Increase or Decrease*
Alaska	4	4	0
Canal Zone	1	2	1
Cuba	4	5	1
Hawaii	27	36	9
Phillipine Islands	11	14	3
Porto Rico	15	13	−2
Canada	117	131	14
Africa	6	8	2
Argentine	3	8	5
Australia	16	25	9
Austria	0	1	1
Belgium	3	4	1
Brazil	6	7	1
British West Indies	3	2	−1
Central America	1	0	−1
Chile	0	1	1
China	42	49	7
Cyprus Islands	1	1	0
Czecho-Slovakia	1	1	0
Denmark	1	2	1
Dutch East Indies	1	1	0
Dutch West Indies	0	1	1
Egypt	4	4	0
England	24	35	11
Europe	1	1	0
France	8	5	−3
Germany	6	9	3
Holland	19	24	5
Hungary	1	2	1
India	15	22	7
Italy	2	3	1
Japan	54	70	16
Jugoslavia	0	2	2
Latvia	1	1	0
Lithuania	1	1	0
Malay	0	1	1
Mexico	5	7	2
Norway	1	3	2
Palestine	2	2	0
Peru	2	2	0
Poland	2	4	2
Roumania	3	2	−1
Russia	9	12	3
Scotland	10	13	3
Serbia	1	1	0
South America	4	0	−4
Spanish Honduras	1	1	0
Sweden	4	6	2
Switzerland	1	2	1
Syria	3	1	−2

Country	*Number as of August 31, 1929*	*Number as of August 30, 1930*	*Increase or decrease*
Turkey	4	3	−1
	9403	9743	

Increase of 340 in total number of subscribers from August 31, 1929, to August 31, 1930.

ONE COPY SUBSCRIPTIONS TO THE JOURNAL OF CHEMICAL EDUCATION

Miscellaneous Expirations

August 30, 1930

No. of years	*Miscellaneous subscribers*	*Science and chemistry teachers*	
1	1417	301	
2	964	281	
3	1036	238	
4	372	158	
5	391	163	
6	398	637	
7	227	143	
8	34	41	
9	7	3	
10		2	
	Total 4846	1967	6813

NUMBER OF CHEMISTRY TEACHERS (OR SCIENCE TEACHERS) WHO HAVE CONTINUOUSLY SUBSCRIBED TO THE JOURNAL OF CHEMICAL EDUCATION

Subscription began		
Year	*Number*	
1924	73	
1925	670	
1926	149	
1927	183	
1928	298	
1929	431	
1930	163	
Total	1967	

NUMBER OF SUBSCRIBERS TO *The Chemistry Leaflet*

Volume III

Year	*Month*	*Number*
1929	October	1266
1929	November	2408
1929	December	3683
1930	January	4990
1930	February	5644
1930	March	6489
1930	April	6718
1930	May	6884
1930	June	7004
1930	July	7024

REPORTS OF COMMITTEES

Reports were received from the committees listed below, and were considered with a view to meeting specific requests for aid. The reports were presented again in full at the Senate Meeting. (See pages 2933–44.)

COMMITTEES REPORTING

Chemical Education of the Non-Collegiate Type.
Chemical Education by Radio.
Chemistry Clubs.
Chemistry Libraries.
Correlation of High-School and College Chemistry.
Labels.
Minimum Equipment for High-School Chemistry.
Naming and Scope of Committees.
Order of Presentation of Recitation and Laboratory.
Preparation of High-School Chemistry Teachers.
Teacher Exchange.
Visual Aids in Chemical Education.
Women's Club Study Course.

NEW BUSINESS

1. Voted to recommend the appointment of M. V. MCGILL as chairman of the Committee on **Chemistry Clubs;** former chairman, G. D. BEAL, resigned.

2. Voted to allot $25.00 for immediate use by the Committee on **Chemistry Libraries.** Resolved, that the Executive Committee agree with Dr. Reed that the preparation of an up-to-date booklist is the more worthwhile. We suggest that he approach such agencies as the American Library Association, the National Research Council and university libraries to use such information as they may already have obtained or are willing to secure.

MISCELLANEOUS BUSINESS

1. The Secretary was instructed to circularize the contributing editors at once, requesting nominations for Editor-in-Chief, since the election must take place prior to July 1, 1931.

2. The Chairman was instructed to request the Council to endorse the program of observance of the Bicentennial of the Birth of George Washington, to take place in 1932.

3. Voted to request those present at the Senate meeting September 10th to consider the selection of a topic for a symposium for the Indianapolis meeting next April.

4. Voted that a committee on **Papers** be authorized, consisting of the Chairman, Secretary, and Editor of the JOURNAL OF CHEMICAL EDUCATION.

5. Voted to interpret the letter ballots of the Senate as favoring nation-wide emphasis on the work of the Committee on **Minimum Equipment,** following the present campaign in the interests of the Committee on **Women's Clubs.**

Minutes of the Meeting of the Senate of Chemical Education

8.30–10.30 A.M., September 10, 1930

REPORTS OF OFFICERS

1. Chairman Swan called attention to the constitutional requirement that all decisive votes be taken by letter ballot. At the same time, he emphasized the great value of group discussions of problems in chemical education.

2. The Secretary reported upon the Letter Ballot of June 21, 1930, which was mailed to the 174 members of the Senate, representing 60 organizations. Accompanying the ballot form, were (*1*) an analysis of the previous letter ballot returns, (*2*) the minutes of the Atlanta meeting, (*3*) three progress reports of the Committee on **Visual Aids** and (*4*) the pamphlet prepared by the Committee on **Women's Clubs** for general distribution.

There were 57 returns from 32 of the Senate membership. This is only slightly more than half the usual number of replies, due probably to the vacation season.

REPORTS OF COMMITTEES

1. **Naming and Scope of Committees:** WILHELM SEGERBLOM, *Chairman*, presented the following report, which was approved: At the Atlanta meeting, three matters were referred to this committee: (*1*) The question of changing the name of the Committee on **Aids to Visual Instruction in Chemistry,** to the Committee on **Visual Aids in Chemical Education.** In accordance with the request of this Committee and with the opinion of the Executive Committee, we passed favorably upon this change and asked the Chairman of the Division to so report to the Editor of the JOURNAL OF CHEMICAL EDUCATION. (*2*) The appointment of a new Committee on **Examinations and Tests.** We approved unanimously of the appointment of such a committee, reported to this effect to the Chairman of the Division, gave him a list of names of suitable members of such a committee, and prepared a sheet of data for the use of the committee giving the steps leading up to suggestions for such a committee, and listing such ideas as had come to light in connection with the discussion of the problem. (*3*) The appointment of a new Committee on **Teaching Load.** We approved unanimously of the appointment of such a committee, and sent the Chairman of the Division similar and even fuller information than in the case of the Committee on **Examination and Tests.**

During the summer, we were asked for help regarding a new chairman for the committee on **Chemistry Clubs** to take the place of Dr. Beal who was obliged to resign. The report of our findings was handed in person to the Chairman of the Division at the beginning of the Cincinnati session, and received attention by the Executive Committee. (See page 2933.)

2. **Visual Aids in Chemical Education:** M. V. MCGILL, *Chairman*, transmitted the following report, by letter, which was approved:

It was found impossible to get the data on films available into the September issue of the JOURNAL OF CHEMICAL EDUCATION. (These data appear in this issue on pages 2916–27.) The committee has other work under investigation, but it has not progressed far enough to make a report upon it.

3. **Chemical Education of the Non-Collegiate Type:** R. E. BOWMAN, *Chairman*, transmitted the following report, by letter:

This report is the result of a circular letter to the members of the committee on **Chemical Education of the Non-Collegiate Type.** Replies were received from all but one member. It embodies their suggestions and conforms, I trust, to the desire of the Senate for the selection of a few definite, clean-cut problems. To quote from the reply of DR. R. E. ROSE, "If others are in the same condition as I am, the whole problem is vague to them and needs outlining, largely because conditions are so different in different localities. With this information before us, I think we could formulate a policy with some certainty that it would be workable."

This Committee desires permission, therefore, to make the following studies: (*1*) To classify the various kinds of non-college grade chemical courses, so that we may see what the schools have to offer. (*2*) With this information, we could go to the industries and ask their opinion as to what kind they can use to the best advantage,

and how. (DR. ALLEN ROGERS.) The above should include a study of Technical Institute, Smith-Hughes, and technical high-school courses, as well as other means by which workers in the chemical industries can improve themselves "on the job" or by which students can be prepared for effective employment or promotion in the industry. After the above objectives have been accomplished, we desire to attempt the far more difficult and costly problem of (*3*) a thorough survey covering the training, length of service, and present opportunities for advancement of plant and laboratory workers of non-college grade. This Committee is not thinking in terms of the academic high-school boy who may or may not study college preparatory chemistry. It is thinking of the training of chemical workers in and for laboratories and plants, who have usually entered industry with little or no knowledge of chemistry whatever, and who have in the past gained their training by the pick-up method.

While there are other problems, the three listed above seem most important to this committee and the sanction of the Council is desired for an immediate attack upon the first two.

It was the opinion of those present that the Committee should devote its activities to studies (1) and (2) for the present, and to report on them before taking up the problem outlined in No. 3.

4. **Chemical Education by Radio:** ROBERT F. MCCRACKEN, *Chairman*, presented the following report, which was approved:

The main activity of the committee since the Atlanta meeting of the A. C. S. has been to increase its general knowledge of the radio world and of radio educational work. The most noteworthy single thing to be mentioned is the sending of a questionnaire to the heads of departments of chemistry and of biochemistry in 315 selected institutions. It was sent in August, and only 141 replies have come in to date, and a few of these are incomplete. A thorough digest of all reports that come in is contemplated, but only a few things learned from the first 141 are mentioned here:

Number of chemistry departments represented on radio programs in recent years, 46 of 139 that replied.....33%

Number of professors who think it worthwhile to try to disseminate knowledge of chemistry by radio, 99 of 135 that replied.....73%

Of these 99, 36 made their answers emphatic with such words as *very, certainly, emphatically so*, etc. Of the other 27 replying, 7 were inclined to think it worthwhile sometimes, 8 were doubtful, 4 declined to express an opinion without more data, 7 thought it not worthwhile, and several failed to make answers clear.

About three-fourths of the 141 making reply qualified and explained their answers, as they were requested to do, and the committee feels that it has a growing lot of valuable information in hand for careful study.

One member of the committee, DR. SAUL B. ARENSON, has been broadcasting about 15 lectures on chemistry each year over WLW as a part of the work of the Ohio School of the Air, and he is serving on the Cincinnati Section's Publicity Committee.

It is gratifying to note that there are now many schools of the air scattered over the states, and that chemical subjects have a place on the programs in practically all of them.

5. **Chemistry Libraries:** RUFUS D. REED, *Chairman*, reported by letter that his committee had outlined their problem essentially according to the plan suggested to him by the Committee on **Naming and Scope of Committees.**

Task 1. Do high schools have departmental libraries apart from the regular libraries? Have a section of the school library devoted to chemistry? Make no provision whatever for books on chemistry outside the text used in class?

Several investigations upon chemistry books in libraries have been made. However, none has been at all complete. Such an investigation to be reliable should be complete and would involve considerable expense for postage and paper. It has been suggested that the state organizations of chemical education take the responsibility of securing this information. This would scatter the expense, but raises the question as to whether these organizations have the funds or the desire to do such work.

Task 2. Are departmental chemistry libraries in high schools desirable? If so, should they be accessible to the students in the rooms devoted to chemistry, or is the school library the proper place?

The committee is of the opinion that such an arrangement is desirable where feasible, because: (*a*) the books would be more accessible when needed than in the library, (*b*) pupils in the laboratory could more quickly consult them. But such a plan does not appear very feasible, because: (*a*) no person would be available to take charge of the departmental library, and assume the responsibility of preserving the books, and (*b*) such a library would be open only part of the time.

Task 3. What is the desirable ratio between the number of reference books on technical, theoretical, and popular books on chemistry?

We have no data upon this problem. The opinion of the committee is divided. An investigation upon this task could be made at the same time *Task 1* is investigated.

Task 4. How much money should be spent for chemistry books by each school?

This would vary according to the size of the school, its budget, demand for books, etc. A range of $30 to $150 is recommended. An investigation as to the amount of money actually spent within the last five years might be worthwhile. Ways of raising money by students for books should be studied.

Task 5. Are existing book lists which have been prepared by various organizations of sufficient value to the inquiring teacher? What is the best list? Is a new list desirable?

Many book lists have been prepared. The committee believes it advisable to revise these lists and to follow the suggestion of DR. HENDRICKS [J. CHEM. EDUC., 5, 867 (1928)] not only to work up a chemistry list, but apportion it among experienced teachers for evaluation. Upon the basis of their evaluations publish a scaled bibliography for high-school chemistry. It would also be desirable to have students evaluate the books. It would be worthwhile to recommend books of value to the teacher, who receives scant consideration in the purchase of high-school books. What books cover the same range of topics? It appears to the Committee that the preparation of an up-to-date book list with the recommendations of both pupils and teachers would be more worthwhile. All the book lists so far reviewed have been incomplete and frequently too hard for high schools. Also, a list of books for teachers would be of value, especially to the teacher and to the one a long way from a public library.

In the discussion which followed, it appeared that Dr. Reed's conclusions received the unanimous approval of those present, and that a book list should be prepared at once (*cf.* action taken by the Executive Committee, page 2933).

6. **Correlation of High-School and College Chemistry:** NEIL E. GORDON, *Chairman*, presented the following report, which was approved:

Since the last meeting of the Senate, each member of your committee has given independent study to the outlines constituting the correlation of high-school and college chemistry, and they are unanimously agreed that Part 1 and Part 2 of the high-school outline and all of the college outline have so few changes to be made to bring them up-to-date, that a new printing could be delayed for two or three years, but that Part 3 of the high-school outline on supplementary reading is in need of immediate revision. Hence, your committee wishes to begin revision of this part at once, and in the mean-

time to invite suggestions and criticisms from the high-school chemistry teachers on Parts 1 and 2 of the high-school outline in order that an entire revision may be made, if warranted.

7. **Labels:** JOHN M. MICHENER, *Chairman*, transmitted the following report by letter:

When the committee was organized early in 1929, it was thought best to first make a survey of the label situation as it then existed. Thirty-two laboratory supply companies were asked to express their opinions concerning the present label books and also what label books they were selling. We received replies from all except one of the thirty-two companies. Most of them expressed their dissatisfaction with the books on the market. Eight of them were selling no such books. A few of the companies were handling two label books. In addition to four label books with rather wide distribution, we found one label book which, while out of print, seems to be better than any of the ones now on the market. As a result of our correspondence, the publishers of the two most widely used books said that they would make revisions in accordance with our final report.

A study was then made of the five label books mentioned above and a list compiled of all the different labels published. These label books differed so much from one another in the labels that were printed that even after a complete list was compiled from them it was thought best to make a survey of the most widely used laboratory manuals to determine what labels should be printed.

A study was then made of nine widely used high-school chemistry manuals and a list compiled showing all chemicals called for by these manuals which would normally be put out on the side shelf.

A second survey was made of college inorganic laboratory manuals. The books examined were all those which were in the chemistry library of the University of Chicago. It was rather surprising to find that only two items (chromic oxide and potassium perchlorate) on this list were not on the high-school list. This similarity undoubtedly indicates a close parallelism between the subject matter in inorganic chemistry in high schools and colleges.

A third study was made of the chemicals that would be expected to be used to such extent in the organic laboratory as to require special labels. In most cases, the chemicals are used directly from the stock bottles, hence, a much smaller number of labels is required than in the inorganic laboratory. Sixty-one items on this list were not found in the inorganic list. Nine of these may well be omitted, leaving only fifty-two additions. This number is so small that it is evident that one label book can be published which will cover the needs of the principal laboratories of the schools.

No study was made of the laboratory manuals in qualitative analysis. It was thought that probably all those items could be found on the other three lists.

There is appended to this report (pages 2938–42) a list of the chemicals which are likely to be found on the side shelf. Thus a good label book should contain labels for these chemicals. The starred chemicals are those which are used by only one of the nine high-school laboratory manuals. The checked chemicals are those that we believe are little used, also the ones marked with # are those that are added to take care of the needs of the organic chemical laboratories.

The committee found a wide variation in the method of naming some chemical compounds, so in such cases we adopted the name which was the most descriptive from a chemical viewpoint. It would seem advisable to organize a committee to secure cooperation with publishers and authors of textbooks in naming compounds alike. Especially is this true of the high-school field.

We are recommending that the size of the label be left to the publisher with the sug-

gestion that labels 3 by 8 centimeters are about the right size. The labels should be interleaved with wax paper. There should be perforations between all labels and the labels should be gummed. The labels should show water of hydration separated from the rest of the formula by a dot.

We believe that the items checked and starred need not be printed as they are little used. There should be several pages of blank labels. It seems advisable to print two labels of each item. We believe that the book should not contain "dead material" and that the buyer should feel that he is going to be able to use nearly all the labels.

We are asking that the committee be continued long enough to make any minor changes in this report that come as a result of a study of it made by each member of the committee and also long enough to submit the essential parts to the four publishers of label books with the view to having them adopt the list essentially, with suggestions as to the make-up of the labels and the book.

Early criticism of the suggested list is invited.

CHEMICALS FOR USE IN INTRODUCTORY COURSES IN GENERAL, INORGANIC, ORGANIC, AND ANALYTICAL CHEMISTRY FOR HIGH SCHOOLS AND COLLEGES

Meaning of symbols used:

* Indicates those items on the high-school list which are used by only one of the nine high-school manuals examined.

\# Indicates those items which are necessary to complete the list for the organic laboratories.

† Indicates those items that in the opinion of the committee may well be omitted besides those marked with *.

†#Acetanilide $C_6H_5NHCOCH_3$
Acetic Anhydride $(CH_3CO)_2O$
Acetone CH_3COCH_3
#Acetyl Chloride CH_3COCl
Acid, Acetic, 36% $HC_2H_3O_2$ CH_3COOH
Acid, Acetic, glacial $HC_2H_3O_2$ CH_3COOH
Acid, Benzoic C_6H_5COOH
Acid, Boric H_3BO_3
*Acid, Butyric $HC_4H_7O_2$ $CH_3(CH_2)_2COOH$
†#Acid, Chloroacetic $CH_2ClCOOH$
†#Acid, Cinnamic $C_6H_5CH{:}CHCOOH$
Acid, Citric $H_3C_6H_5O_7$ $(CO_2HCH_2)_2C(OH)COOH$
Acid, Formic, 90% $HCOOH$
#Acid, Hydrobromic HBr
Acid, Hydrochloric HCl
#Acid, Hydriodic HI
*Acid, Lactic, 85% $HC_3H_5O_3$ $CH_3CH(OH)CO_2H$
Acid, Nitric HNO_3
Acid, Nitric, fuming $HNO_3 + NO_2$
†#Acid, Oleic $C_{17}H_{33}COOH$
Acid, Oxalic $(COOH)_2$
†#Acid, Palmitic $CH_3(CH_2)_{14}COOH$
Acid, Phosphoric, Ortho H_3PO_4
*Acid, Picric $HOC_6H_2(NO_2)_3$
†#Acid, Rosolic $C_{20}H_{16}O_3$
Acid, Salicylic $HC_7H_5O_3$ HOC_6H_4COOH
†Acid, Stearic $HC_{18}H_{35}O_2$
†#Acid, Succinic $CH_3(CH_2)_{16}COOH$ $HOOCCH_2CH_2CO_2H$
Acid, Sulfanilic $NH_2C_6H_4SO_3H{\cdot}H_2O$
Acid, Sulfuric H_2SO_4
#Acid, Sulfuric, fuming $H_2S_2O_7$
Acid, Tannic $C_{14}H_{10}O_9$
Acid, Tartaric $H_2C_4H_4O_6$ $[CH(OH)COOH]_2{\cdot}H_2O$
*Acid Blue (Aniline Color)
Albumin, Egg
Alcohol, Amyl $CH_3(CH_2)_3CH_2OH$
Alcohol, Ethyl, 95% C_2H_5OH
#Alcohol, Ethyl, absolute C_2H_5OH
Alcohol, Methyl CH_3OH
Alizarin $C_6H_4(CO)_2C_6H_2(OH)_2$
Aluminum, filings Al
Aluminum, gran. Al
Aluminum, powd. Al
Aluminum Acetate, basic $Al(C_2H_3O_2)_2OH$
Aluminum Chloride $AlCl_3{\cdot}6H_2O$

#Aluminum Chloride, anhyd. $AlCl_3$
Aluminum Potassium Sulfate $Al_2(SO_4)_3K_2SO_4 \cdot 24H_2O$
Aluminum Sodium Sulfate $Al_2(SO_4)_3Na_2SO_4 \cdot 24H_2O$
Aluminum Sulfate $Al_2(SO_4)_3 \cdot 18H_2O$
#Ammonium Acetate $NH_4C_2H_3O_2$
Ammonium Carbonate $(NH_4)_2CO_3 \cdot H_2O$
Ammonium Chloride NH_4Cl
*Ammonium Dichromate $(NH_4)_2Cr_2O_7$
Ammonium Hydroxide NH_4OH
Ammonium Molybdate $(NH_4)_2MoO_4$
Ammonium Nitrate NH_4NO_3
Ammonium Oxalate $(NH_4)_2C_2O_4 \cdot H_2O$
Ammonium Monohydrogen Phosphate $(NH_4)_2HPO_4$
Ammonium Sulfate $(NH_4)_2SO_4$
Ammonium Sulfide, light $(NH_4)_2S$
Ammonium Thiocyanate NH_4CNS
†#Ammonium Tartrate $(NH_4)_2C_4H_4O_6$
#Amylene $CH_3(CH_2)_2CH:CH_2$
Aniline $C_6H_5NH_2$
#Anthracene $C_6H_4:(CH)_2:C_6H_4$
Antimony, powd. Sb
Antimony Trichloride $SbCl_3$
*Antimony Trioxide Sb_2O_3
*Antimony Trisulfide Sb_2S_3
Antimonyl Potassium Tartrate $K(SbO)C_4H_4O_6 \cdot {}^1/_2H_2O$
Arsenic, powd. As
Arsenic Trioxide (Arsenous Acid) As_2O_3
Arsenic Trichloride $AsCl_3$
Asbestos $Mg_3Ca(SiO_3)_4$
Barium Chloride $BaCl_2 \cdot 2H_2O$
Barium Hydroxide $Ba(OH)_2 \cdot 8H_2O$
Barium Nitrate $Ba(NO_3)_2$
*Barium Peroxide BaO_2
*Barium Sulfate $BaSO_4$
*Barium Sulfide BaS
Benzene C_6H_6
†Bismarck Brown
Bismuth, lumps Bi
Bismuth Chloride $BiCl_3$
*Bismuth Nitrate $Bi(NO_3)_3 \cdot 5H_2O$
Bleaching Powder $CaOCl_2$
Bromine Br_2
Bromine water $Br_2 + H_2O$
#Bromine in Carbon Tetrachloride $Br_2 + CCl_4$
†Cadmium, sticks Cd
*Cadmium Carbonate $CdCO_3$
Cadmium Chloride $CdCl_2 \cdot 2H_2O$
Cadmium Nitrate $Cd(NO_3)_2 \cdot 4H_2O$
*Cadmium Sulfate $CdSO_4 \cdot 4H_2O$
Calcium, turnings Ca
Calcium Carbide CaC_2
Calcium Carbonate (Marble Chips) $CaCO_3$
Calcium Carbonate, powd. $CaCO_3$
Calcium Chloride, anhyd. $CaCl_2$
Calcium Chloride $CaCl_2 \cdot 6H_2O$
*Calcium Cyanamide (Cyanamide) $CaCN_2$
Calcium Fluoride CaF_2
Calcium Hydroxide $Ca(OH)_2$
Calcium Hypochlorite $Ca(ClO)_2 \cdot 4H_2O$
Calcium Nitrate $Ca(NO_3)_2 \cdot 4H_2O$
Calcium Oxide (Quicklime) CaO
*Calcium Hydrogen Phosphate (Mono) $CaH_4(PO_4)_2 \cdot H_2O$
#Calcium Phosphate $Ca_3(PO_4)_2$
Calcium Sulfate (Gypsum) $CaSO_4 \cdot 2H_2O$
Calcium Sulfate (Plaster of Paris) $CaSO_4 \cdot {}^1/_2H_2O$
Carbon C
#Carbon, decolorizing C
Carbon Disulfide CS_2
Carbon Tetrachloride CCl_4
*Casein
Charcoal, Animal, gran. $C + Ca_3(PO_4)_2$
Charcoal, Wood, lumps C
Charcoal, Wood, powd. C
Chlorine Water $Cl_2 + H_2O$
Chloroform $CHCl_3$
*Chrome Ore (Chromite) $Fe(CrO_2)_2$
Chromic Oxide Cr_2O_3
*Chromic Chloride (green) $CrCl_3 \cdot 6H_2O$
Chromic Potassium Sulfate $Cr_2(SO_4)_3K_2SO_4 \cdot 24H_2O$
Chromic Sulfate $Cr_2(SO_4)_3 \cdot 5H_2O$
*Chromous Carbonate $CrCO_3$
#Cleaning Mixture $Na_2Cr_2O_7 + H_2SO_4$
*Cloth, cotton, colored
*Cloth, cotton, white
†Cloth, wool
*Coal
*Cobalt, pellets Co
Cobaltous Chloride $CoCl_2 \cdot 6H_2O$
Cobaltous Nitrate $Co(NO_3)_2 \cdot 6H_2O$

Cochineal
†Collodion
Congo Red
Copper, foil Cu
Copper, turnings Cu
#Copper, wire Cu
#Cotton
*Cupric Acetate $Cu(C_2H_3O_2)_2 \cdot H_2O$
*Cupric Bromide $CuBr_2$
*Cupric Carbonate, basic $CuCO_3Cu(OH)_2$
Cupric Chloride $CuCl_2 \cdot 2H_2O$
Cupric Nitrate $Cu(NO_3)_2 \cdot 6H_2O$
Cupric Oxide CuO
Cupric Sulfate $CuSO_4 \cdot 5H_2O$
#Cuprous Chloride Cu_2Cl_2
#Cuprous Cyanide $Cu_2(CN)_2$
*Dextrin $(C_6H_{10}O_5)_x$
Dextrose (Glucose) $C_6H_{12}O_6$
Ether, Ethyl $(C_2H_5)_2O$
#Ethyl Acetate $CH_3COOC_2H_5$
*Ethyl Benzoate $C_6H_5COOC_2H_5$
†#Ethyl Bromide C_2H_5Br
Fehling's Solution "A"
Fehling's Solution "B"
Ferric Ammonium Citrate
*Ferric Ammonium Sulfate $Fe_2(SO_4)_3(NH_4)_2SO_4 \cdot 24H_2O$
Ferric Chloride $FeCl_3 \cdot 6H_2O$
*Ferric Nitrate $Fe(NO_3)_3 \cdot 9H_2O$
*Ferric Oxalate $Fe_2(C_2O_4)_3$
*Ferric Oxide Fe_2O_3
Ferric Sulfide (Pyrite) FeS_2
*Ferrous Ammonium Sulfate $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$
Ferrous Chloride $FeCl_2 \cdot 4H_2O$
*Ferrous Oxalate $FeC_2O_4 \cdot 2H_2O$
Ferrous Sulfate $FeSO_4 \cdot 7H_2O$
*Ferrous Sulfide FeS
Formaldehyde, 40% HCHO
#Fuchsin
*Gallein (Aniline color)
Gasoline
Gelatin
Glass Wool
Glycerin $C_3H_5(OH)_3$
†Graphite C
*Gum Arabic
*Gum Camphor $C_{10}H_{16}O$
Hydrogen Peroxide, 3% H_2O_2
*Hydrone (Calcium Hydride) CaH_2
*Hydroquinone $C_6H_4(OH)_2$
#Hydroxylamine NH_2OH
#Hydroxylamine Acetate $NH_2OH \cdot HC_2H_3O_2$
#Hydroxylamine Hydrochloride $NH_2OH \cdot HCl$
*Indigo $C_{16}H_{10}O_2N_2$
Iodine I_2
*Iodoform CHI_3
Iron, filings Fe
Iron, powd. Fe
*Iron, wire Fe
*Kaolin $Al_2H_2(SiO_4)_2 \cdot H_2O$
Kerosene
Lactose $C_{12}H_{22}O_{11} \cdot H_2O$
*Lampblack C
†Lard
Lead, foil Pb
Lead, gran. Pb
Lead Acetate $Pb(C_2H_3O_2)_2 \cdot 3H_2O$
Lead Carbonate, basic $2PbCO_3Pb(OH)_2$
Lead Dioxide PbO_2
Lead Monoxide PbO
Lead Nitrate $Pb(NO_3)_2$
Lead Tetroxide (Red Lead) Pb_3O_4
*Lead Sulfide (Galena) PbS
#Levulose (Fructose) $C_6H_{12}O_6$
Lithium Chloride LiCl
Lithium Nitrate $LiNO_3 \cdot 3H_2O$
Litmus Cubes
Litmus, Blue
Litmus, Red
Logwood
Magnesium, powd. Mg
Magnesium, ribbon Mg
*Magnesium, turnings Mg
Magnesium Carbonate $MgCO_3 \cdot 3H_2O$
Magnesium Chloride $MgCl_2 \cdot 6H_2O$
Magnesium Oxide MgO
Magnesium Sulfate $MgSO_4 \cdot 7H_2O$
#Magnesium Sulfate, anhyd. $MgSO_4$
†Malachite Green
*Maltose $C_{12}H_{22}O_{11} \cdot H_2O$
Manganese Dioxide MnO_2
*Manganous Chloride $MnCl_2 \cdot 4H_2O$
*Manganous Sulfate $MnSO_4 \cdot 4H_2O$
Mercury Hg
Mercuric Chloride $HgCl_2$
*Mercuric Iodide HgI_2
Mercuric Nitrate $Hg(NO_3)_2 \cdot 2H_2O$

Mercuric Oxide HgO
Mercurous Nitrate $HgNO_3 \cdot 2H_2O$
Methyl Orange
†Methyl Violet
†Methylene Blue
#Milk
#Millon's Solution
#Naphthalene $C_{10}H_8$
Naphthol, Alpha $C_{10}H_7OH$
*Naphthol, Beta $C_{10}H_7OH$
*Naphthylamine, Alpha $C_{10}H_7NH_2$
*Nessler's Solution $K_2(HgI_4)$
*Nickel Ni
Nickel Chloride $NiCl_2 \cdot 6H_2O$
Nickel Nitrate $Ni(NO_3)_2 \cdot 6H_2O$
Nickel Sulfate $NiSO_4 \cdot 7H_2O$
*Nigrosine Black
†Oil, Coconut
†Oil, Cottonseed
Oil, Linseed
Oil, Olive
*Pancreatin
Paraffin
*Permutite
†Petrolatum
#Phthalic Anhydride $C_6H_4(CO)_2O$
#Phenol C_6H_5OH
Phenolphthalein $C_{20}H_{14}O_4$
Phosphorus, Yellow P
Phosphorus, Red P
#Phosphorus Pentachloride PCl_5
*Phosphorus Pentoxide P_2O_5
#Phosphorus Trichloride PCl_3
Potassium K
Potassium Bromide KBr
Potassium Carbonate $K_2CO_3 \cdot 2H_2O$
#Potassium Carbonate, anhyd. K_2CO_3
Potassium Chlorate $KClO_3$
Potassium Chloride KCl
Potassium Chromate K_2CrO_4
#Potassium Cyanate KCNO
Potassium Cyanide KCN
Potassium Dichromate $K_2Cr_2O_7$
Potassium Ferricyanide $K_3Fe(CN)_6$
Potassium Ferrocyanide $K_4Fe(CN)_6 \cdot 3H_2O$
#Potassium Hydrogen Sulfate $KHSO_4$
#Potassium Hydrogen Sulfite $KHSO_3$
Potassium Hydrogen Tartrate $KHC_4H_4O_6$
Potassium Hydroxide KOH
#Potassium Hydroxide, alcoholic KOH
Potassium Iodide KI
Potassium Iodide-Starch KI + starch
Potassium Nitrate KNO_3
Potassium Oxalate $K_2C_2O_4 \cdot H_2O$
Potassium Perchlorate $KClO_4$
Potassium Permanganate $KMnO_4$
#Potassium Phosphate K_3PO_4
Potassium Sodium Tartrate $KNaC_4H_4O_6 \cdot 4H_2O$
Potassium Sulfate K_2SO_4
Potassium Thiocyanate KCNS
*Primuline Yellow
*Pumice
Pyrogallol (Pyrogallic Acid) $C_6H_3(OH)_3$
#Rayon
†Rennet
†Resorcinol $C_6H_4(OH)_2$
†Rosin
*Rubber
Sand SiO_2
#Schiff's Reagent
†Shellac, Orange
*Shellac, White
#Silk
*Silver Ag
*Silver Acetate $AgC_2H_3O_2$
Silver Nitrate $AgNO_3$
*Silver Oxide Ag_2O
*Silver Sulfate Ag_2SO_4
Soap, Castile
Sodium Na
Sodium Acetate $NaC_2H_3O_2 \cdot 3H_2O$
#Sodium Acetate, fused $NaC_2H_3O_2$
*Sodium Ammonium Hydrogen Phosphate $NaNH_4HPO_4 \cdot 4H_2O$
Sodium Benzoate $NaC_7H_5O_2$
Sodium Borate (Borax) $Na_2B_4O_7 \cdot 10H_2O$
Sodium Bromide NaBr
Sodium Calcium Hydroxide (Soda Lime) $NaOH + Ca(OH)_2$
Sodium Carbonate $Na_2CO_3 \cdot 10H_2O$
*Sodium Carbonate, anhyd. Na_2CO_3
*Sodium Chlorate $NaClO_3$
Sodium Chloride NaCl
*Sodium Chloride (Rock Salt) NaCl
Sodium Chromate $Na_2CrO_4 \cdot 10H_2O$
#Sodium Dichromate $Na_2Cr_2O_7 \cdot 2H_2O$
#Sodium Cyanide NaCN

*Sodium Fluoride NaF
#Sodium Formate $NaCHO_2$
Sodium Dihydrogen Phosphate $NaH_2PO_4 \cdot H_2O$
Sodium Hydrogen Carbonate $NaHCO_3$
Sodium Hydrogen Sulfate $NaHSO_4$
*Sodium Hydrogen Sulfite $NaHSO_3$
Sodium Monohydrogen Phosphate $Na_2HPO_4 \cdot 12H_2O$
Sodium Hydroxide NaOH
#Sodium Hypochlorite NaClO
Sodium Iodide NaI
Sodium Nitrate $NaNO_3$
Sodium Nitrite $NaNO_2$
#Sodium Nitroprusside $Na_2Fe(CN)_5NO \cdot 2H_2O$
*Sodium Oleate $NaC_{17}H_{33}CO_2$
Sodium Peroxide Na_2O_2
Sodium Silicate (Water Glass) $Na_2Si_4O_9$
*Sodium Stearate $NaC_{17}H_{35}CO_2$
Sodium Sulfate $Na_2SO_4 \cdot 7H_2O$
Sodium Sulfide Na_2S
Sodium Sulfite $Na_2SO_3 \cdot 7H_2O$
Sodium Thiocyanate NaCNS
Sodium Thiosulfate (Sodium Hyposulfite) $Na_2S_2O_3 \cdot 5H_2O$
Stannic Chloride $SnCl_4$
*Stannic Oxide SnO_2
Starch, Corn $(C_6H_{10}O_5)_x$
†Starch, Potato $(C_6H_{10}O_5)_x$
*Starch, Rice $(C_6H_{10}O_5)_x$
*Starch, Wheat $(C_6H_{10}O_5)_x$
Steel Wool Fe
Strontium Nitrate $Sr(NO_3)_2 \cdot 4H_2O$
Sucrose $C_{12}H_{22}O_{11}$
Sulfur, flowers S
Sulfur, roll, lump S
*Thermit, black $Fe + Al_2O_3$
*Thermit Igniting Mixture
Tin, gran. Sn
Tin, foil Sn
*Tin, shot Sn
*Tin, sticks Sn
#Tollen's Solution "A"
#Tollen's Solution "B"
#Toluene $C_6H_5CH_3$
*Toluidine, Ortho $CH_3C_6H_4NH_2$
*Turmeric
Turpentine $C_{10}H_{16}$
#Urea $(NH_2)_2CO$
†Vaseline
*Wood's Metal
Wood splints
#Wool
Zinc, dust Zn
Zinc, gran. Zn
*Zinc Acetate $Zn(C_2H_3O_2)_2 \cdot 3H_2O$
*Zinc Carbonate $ZnCO_3$
#Zinc Chloride, anhyd. $ZnCl_2$
Zinc Nitrate $Zn(NO_3)_2 \cdot 6H_2O$
Zinc Oxide ZnO
Zinc Sulfate $ZnSO_4 \cdot 7H_2O$

JOHN M. MICHENER, *Chairman*, Wichita High School East, Wichita, Kans.
M. F. STUBBS, Tennessee Wesleyan College, Athens, Tenn.
L. R. LITTLETON, Emory and Henry College, Emory, Va.
W. O. WALKER, A. O. Smith Corporation, Milwaukee, Wis.

8. **Minimum Equipment for High-School Chemistry.** J. H. JENSEN, *Chairman*, transmitted the following report, which was approved:

A list of minimum equipment for the use of the individual pupil is now ready to be submitted to the Senate for such action as it may deem advisable.

This list has undergone two revisions on basis of frequency of occurrence, suggestions received from the members of the Senate of Chemical Education, and from instructors in high schools of the larger cities. The list has also been checked with the recent list of equipment that I have been able to secure from the various state departments of education. An effort has been made to be as specific as possible so that the supply houses will of necessity be required to bid on the same type and quality of a given item. Such specifications are also necessary for the inexperienced instructor that predominate in the small high school. The committee is primarily concerned with these needs of the schools with an enrolment of 150 or less. Such schools have only one class in chemistry with an enrolment of 8 to 10 pupils. I trust that the list may be satisfactory. If any errors are found or more definite specifications can be given than

we have indicated in the present list, the committee would appreciate such corrections or additions.

The list of chemicals will be submitted to the Senate and to high-school instructors in an effort to determine the present practice in regard to quantity and grade used. As noted, this list includes the more commonly used chemicals based on fifteen of the more recent textbooks in chemistry and on twenty-eight of the recent lists as prepared by various state departments of education. Judging from a preliminary feeler sent out in connection with the list of minimum equipment, there is considerable difference of opinion in regard to grades of chemicals required for high-school use. Most of the high-school instructors also indicated that they do not favor the use of chemical kits. As a next step, I will ask the members of the committee to check the commonly used manuals in order to determine what grade of chemicals will serve the purpose and just how much will be required for the use of each pupil. I hope that we may be able to indicate about how many pupils a 6-lb. bottle of hydrochloric acid may be reasonably expected to serve.

9. **Order of Presentation of Recitation and Laboratory Work:** FRANK M. GREENLAW, *Chairman*, requested the Secretary to report that the Committee is engaged in studying measurable values derived from laboratory instruction in high-school chemistry as a preliminary to further testing.

10. **Preparation of High-School Chemistry Teachers:** A. J. CURRIER, *Chairman*, presented a report, which was approved. (*Note: Since this report served as the basis for one of the symposium papers, it will be published with the latter in an early issue of the* JOURNAL OF CHEMICAL EDUCATION).

11. **Teacher Exchange:** B. S. HOPKINS presented a progress report which was accepted. Teachers who are interested in an exchange plan are urged to communicate with some member of the Committee.

12. **Women's Club Study Course in Chemistry,** HARRISON HALE, *Chairman*, presented the following report, which was approved:

Your Committee on the Women's Club Study Course begs to report that considerable interest has been manifested in the course which is being offered in American chemistry and some registrations have already been received for the work to begin in the fall. There have been numerous inquiries and the coöperation of each member of the Society in bringing this matter before clubs that might be interested or individual members of these clubs is essential to the full success of the work of this committee. It will be recalled that this was made one of the major projects of our division.

We have been pleased to receive requests for information in regard to this work from organizations of both men and women and this course will be used in some cases by such groups.

The committee has been fortunate in having added to its membership the following:

MRS. JOHN D. SHERMAN, Olin Hotel, Denver, Colo.
MISS CLARA DEMILT, Professor of Chemistry, H. Sophie Newcomb College, New Orleans, La.
MRS. PAULINE BEERY MACK, of Pennsylvania State College, Editor of *The Chemistry Leaflet*.

Mrs. Sherman was president of the General Federation of Women's Clubs in the early days of the work of this committee and her interest has been a constant help.

The committee is indebted to the News Service for the splendid help which it has rendered and to Dr. A. M. Harding, Director of the General Extension, University of Arkansas, for the coöperation given by the Bureau of Women's Clubs, which has charge of registration for this course. The Bureau has given freely of its time and attention to this work and has waived its usual registration fee.

We shall appreciate the fullest coöperation in our efforts to make this course a success.

Dr. Segerblom suggested that individual Women's Clubs might be stirred up to introduce this course if a letter were received from their respective State Federations—such a letter to stress two points: (*a*) the advantages of giving such a course and (*b*) giving to the clubs the names of two or three chemists in that state who had signified their willingness to conduct such a course.

NEW BUSINESS

Members of the Senate who were present voted in favor of arranging a general program on some phase of chemical education to be held Tuesday morning (March 31, 1931) at the Indianapolis meeting of the A. C. S.

Adjourned 10.30 A.M.

R. A. BAKER, *Secretary*

Minutes of the Business Meeting of the Division of Chemical Education

11 A.M., Sept. 11, 1930

1. The Secretary's report covering the recent meetings of the Executive Committee and of the Senate was approved.

2. The Treasurer's report of receipts and expenditures since January 1st was approved. (See note under Treasurer's Report on page 2929.)

3. The resolutions committee made the following report, and the three resolutions were unanimously adopted:

(*1*) The Division of Chemical Education, American Chemical Society, expresses its vigorous protest against the summary dismissal in June of this year of members of the faculty of state supported schools in Mississippi without charges being preferred or reasons publicly assigned. Apparently this move was dictated entirely by political motives with no relation to the educational interests of the institution or of the state.

The Chancellor of the university and some of the most able men in his faculty were affected. Among these was DR. J. N. SWAN, Chairman of this Division, who has served long and efficiently as professor of chemistry.

This action has aroused indignant opposition within the state, as expressed by educational leaders and by the press. We wish to add our protest to theirs. Further, we caution members of this Division against accepting positions in these institutions, until steps have been taken to prevent a recurrence of this unfortunate situation. We wish also to raise the question of the acceptance in the future of transfer credit from these institutions unless this condition is corrected.

(*2*) The Division of Chemical Education, American Chemical Society, wishes to express again its deep appreciation of the interest and generosity of Mr. and Mrs. F. P. Garvan which have made it possible to bring a recognition of the fundamental importance of chemistry in our American life to a steadily increasing number.

The assistance of The Chemical Foundation in the publication and distribution not only of research work but also of books furnishing authentic information to many thousands has been of untold value. An expression of the appreciation of the Division to all who have contributed to this understanding of chemistry is hereby given.

(*3*) The Division of Chemical Education, American Chemical Society, wishes to express its sincere appreciation of the thoughtfulness, courtesy, and hospitality of the Cincinnati Section, which have added so much to the convenience and pleasure of this meeting. We shall ever carry with us pleasant memories of the days spent here.

4. The Secretary was instructed to convey a vote of thanks to those who participated in a most successful symposium on "The Qualifications of Chemistry Teachers."

5. The Local Secretary, FATHER E. J. MORGAN, received a vote of thanks for his efficient service prior to and during the Cincinnati meeting.

6. Voted to recommend to the Senate the consideration of laying early emphasis on the work of the Committee on the **Preparation of High-School Chemistry Teachers.**

7. The Nominating Committee, consisting of WILHELM SEGERBLOM (*Chairman*), J. SAM GUY and HARRY N. HOLMES, presented nominations for officers, prefacing their report with the statement that the members of the Committee believed heartily in the general principle of rotation of office, but that, under the present unusual conditions, they felt it would be distinctly appropriate for the Division to re-elect its present officers. There being no other nominations, DR. A. P. SY was called to the chair temporarily. The Secretary was instructed to cast a unanimous ballot for the following:

Chairman, J. N. SWAN
Vice-Chairman, M. V. MCGILL
Secretary, R. A. BAKER
Treasurer, ROSALIE M. PARR

Adjourned 12 M.

R. A. BAKER, *Secretary*

ASSOCIATION OF SCIENCE TEACHERS OF THE MIDDLE STATES AND MARYLAND

The tenth annual meeting of the Association of Science Teachers of the Middle States and Maryland will be held at Haddon Hall, Atlantic City, New Jersey, at the end of Thanksgiving week. The president of the Association is MR. JESSE WHITSIT, Dewitt Clinton High School, New York City, and the secretary-treasurer is MISS ELIZABETH W. TOWLE, Bryn Mawr, Pa.

On Friday, November 28th, there will be an Information Table at the hotel, marked "Association of Science Teachers," where tickets for the subscription luncheon on Saturday may be obtained and where arrangements may also be made for those who wish it to be seated with other members of the Association at the subscription dinner on Friday evening.

Those who are planning to attend the Science Conference on Saturday morning are urged to register at the Information Table, where there will also be an opportunity of meeting other science teachers.

The program for Science Conference on Saturday morning, November 29th, at 10.00 A.M. is as follows:

Reports on present status of matters covered in previous meetings.

1. "Syllabi in Biology, Chemistry and Physics," DR. JOSEPH M. JAMESON, Girard College, Philadelphia, Pa.
2. "Relative Value of Various Methods of Securing Objectivity in Science," DR. M. LOUISE NICHOLS, South Philadelphia High School for Girls.

Address—"Teaching Science as a Way of Life," DR. JOHN L. TILDSLEY, District Superintendent of High Schools, New York City.

Discussion.

There will be a subscription luncheon ($1.50 per plate) at 1.00 P.M. at Haddon Hall. The group will be addressed by Dr. William Seifriz, Botanical Laboratory, University of Pennsylvania, on "The Romance of Science."

CENTIGRADE-FAHRENHEIT TEMPERATURE CONVERSION

JOSEPH G. BLANN, DAVID STARR JORDAN HIGH SCHOOL, LOS ANGELES, CALIFORNIA

In introducing conversion of temperatures to the student, the manner, both in textbook arrangement and pedagogic presentation, appears to be universally a standard one. Yet, the attendant results are a vague, hazy perception and confusion for the student, whether relying upon an independent derivation, as occasion demands, or upon memory of formulas more or less kaleidoscopic in nature, as are the formulas encountered in this work. Most individuals find a need of momentary re-orientation when required to make these conversions, of "starting from the beginning" in order to set the formula aright in mind, while a few may even find it necessary to consult, from time to time, a source of information for the needed formula. These difficulties may be attributed essentially to the 32° transposition involved, which seems to be the barrier.

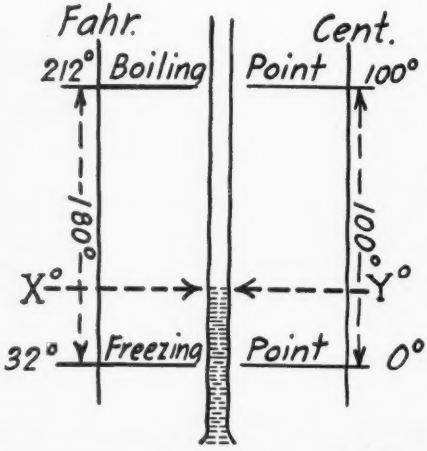
This article not only aims to eliminate restricting ourselves to specific formulas, but especially to indicate a much simpler method of temperature conversion. Rather than commencing at the freezing point of water on the two scales, as has been the custom, let us consider the boiling points. As shown by the figure, between the boiling and freezing point of water, there are 180 degrees Fahrenheit and likewise 100 degrees centigrade.

Then, $100°C. = 180°F.$

or, $$1°C. = \frac{180}{100}\,°F. = \frac{9}{5}°F.$$

and, $$1°F. = \frac{5}{9}°C.$$

We are now in a position to carry out temperature conversions freely, best shown by two examples considered below.



(1) $20°C. = ?°F.$

$20°C.$ is $80°$ below the boiling point.

Therefore, it is $80 \times \frac{9}{5}°F.$, or $144°F.$ below the boiling point, which is $68°F.$

$\therefore 20°C. = 68°F.$

(2) $23°F. = ?°C.$

$23°F.$ is $189°$ below the boiling point.

Therefore, it is $189 \times \frac{5}{9}°C.$, or $105°C.$ below the boiling point, which is $-5°C.$

$$\therefore 23°\text{F.} = -5°\text{C.}$$

For the individual more mathematically minded, a more direct form of proportion can be introduced, *viz.*:

$$\frac{212 - x}{212 - 32} = \frac{100 - y}{100 - 0}$$

or,

$$\frac{212 - x}{180} = \frac{100 - y}{100}$$

where x and y represent the Fahrenheit and Centigrade temperatures, respectively.

The points in favor of this method are the comparative simplicity, directness, clarity, and lack of dependence upon memory of formulas or encountered delay in re-orientation to the formulas. The graphical, geometric approach to the idea of proportion tends to make its use in other problem work in elementary chemistry more effective. At the same time a new source of problem material is gained with the introduction of temperature conversion in the study of proportion in courses in plane geometry.

Glass Is a Liquid, Chemist Asserts. Glass, which has been stuff of mystery and secrecy for thousands of years, is now explained in scientific terms, and the explanation is as much like magic as the Assyrian formulas. Glass is a liquid, George W. Morey, of the Carnegie Institution of Washington, has concluded. It is a liquid in a state of suspended animation.

Only three ingredients mixed in the proper proportions and melted and cooled can produce this unique state of matter, and it is one of the strange facts of prehistory that this narrowly limited combination was discovered by primitive men, probably in Syria, perhaps as far back as 5500 B.C.

"To keep the secret of the proper proportions of the various ingredients of glassware has been the prime motive of the secrecy and mysticism within which glass-manufacture has been shrouded from the earliest times to the past decade, and from the influence of which the industry has not yet freed itself," declares Mr. Morey in *Art and Archaeology*. "The reason for this restricted composition range is to be found in the physico-chemical relationship of the ingredients, and once these relationships are known, long-cherished glass formulas become obvious deductions from them. These physico-chemical relationships have only recently been discovered by workers in the Geophysical Laboratory of the Carnegie Institution of Washington."

The secret is simple, once it has been found out, Mr. Morey points out. The three ingredients of glass (lime, soda, and sand) when mixed in certain proportions have a particularly low melting point. As a result of this, by the time the mixture reaches its freezing temperature it is so stiff and viscous that the molecular change which would cause the glass to become opaque can hardly take place. Too little or too much of any of the ingredients and the glass becomes opaque, not durable, or otherwise worthless.

Throughout the cooling process, the mixture remains a liquid, Mr. Morey states, and "glass may best be defined as a liquid whose rigidity is great enough to enable it to be put to certain useful purposes."—*Science Service*

THE USE OF A ZINC WIRE SPIRAL AS A JONES REDUCTOR

G. FREDERICK SMITH AND JOSEPH RICH, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS

Introduction

The amalgamated granulated zinc Jones reductor is used extensively in the volumetric determination of the following elements after reduction to the lower valences indicated, iron (11), titanium (111), molybdenum (111), vanadium (11), chromium (11), and uranium (< IV). Because of the previous inability to obtain pure zinc wire, granulated zinc has been replaced with coils of aluminum wire or aluminum sheet for some of these reductions, particularly that of iron, because of the obvious disadvantages in the use of granulated zinc. The aluminum so used invariably contained enough iron to make a troublesome blank correction necessary.

This present paper has for its object the description of the use of pure zinc wire as a Jones reductor, calling attention to its ready availability and indicating necessary precautions in its preparation for use and testing its accuracy in actual service as a substitute for granulated zinc in the usual type of Jones reductor.

Zinc Wire Spiral Analyses, Preparation of Spiral and Amalgamation

For a description of the use of the old type of Jones reductor and bibliographic references to the same, the paper by Lundell and Knowles (*1*) serves. Further references to the literature are unnecessary. As far as could be learned no previous description of the use of zinc wire to substitute for the granular zinc of the Jones reductor has been given. Zinc rod is unsuitable both because of insufficient surface exposed and an unsatisfactory porosity especially after a short period of use.

The zinc wire used in the present paper was supplied through the courtesy of W. H. Bassett, metallurgical manager of The American Brass Company, Waterbury, Connecticut. A second sample was obtained through the assistance of W. T. Isbell of the St. Joseph Lead Company, Bonne Terre, Missouri. The analyses are found in Table I.

TABLE I

The Analysis of Commercial High-Grade Zinc to Be Used in Spiral Zinc Wire Reduction

Material	*% Pb*	*% Cu*	*% Fe*	*As,Sb,Sn*	*% Cd*	*% Al*
Bunker Hill Zinc St. Joseph Lead Co.	0.0075	0.0006	0.0017	Free	0.0019	0.0007
Anaconda Zinc American Brass Co.	0.003	....	0.001	..	0.000	....

Both samples of zinc shown in Table I proved satisfactory for the preparation of zinc wire spiral reductors. The samples were supplied in the form of wire approximately 3 mm. in diameter, 10 cm. of which weighed approximately 5.7 grams. A coil made from 715 mm. weighing 48.5 grams was made by turning $10^1/_2$ turns around a 19-mm. cork borer with

a vertical extension of 4–5 inches to serve as a handle to insert and withdraw the reductor in use. A coil so formed just passes conveniently through the neck of a 300-cc. Erlenmeyer flask.

Zinc wire of the purity employed shows a marked tendency to crystallize due to bending. If annealed at 125°C. for a few hours this property is lost to an appreciable extent but upon solution in acid, small portions scale off into the solution being reduced and defeat the attempt to remove and wash the entire excess of zinc employed. Annealing together with amalgamation prevents both these tendencies completely.

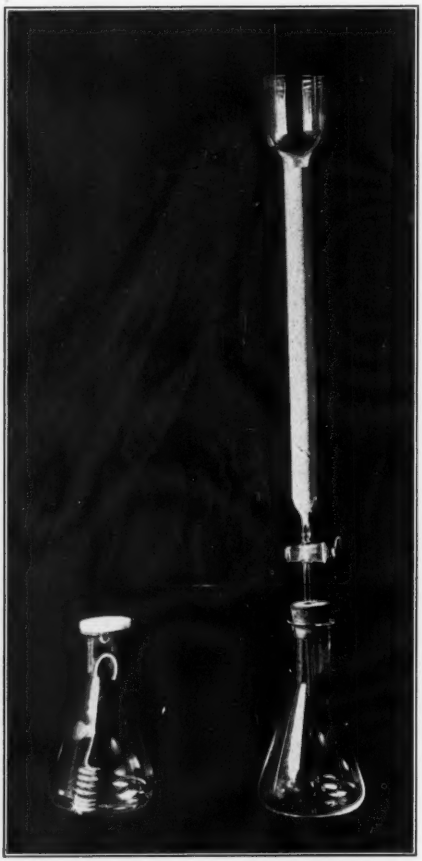
The zinc spiral reductor is amalgamated by immersion during a ten-minute interval in a 10% solution of mercuric nitrate acidified with 5% by volume concentrated nitric acid, using the solution at room temperature and shaking the 300-cc. Erlenmeyer flask containing the spiral and solution at frequent intervals. The solution for amalgamation should just immerse the spiral part of the coil in the amalgamating liquid. The gain in weight of the coil, when corrected for the amount of zinc dissolved, shows a spiral reductor treated in this way to be amalgamated to the extent of 1–2%. A coil so treated while fairly flexible breaks if distorted too highly following amalgamation. Such coils are known to be more active if treated by immersion in an acid solution containing a few mg. of platinum. The coils used in this work were not so treated. The per cent amalgamation increases in a given coil during use because of the solution of zinc but as with amalgamated granular zinc an increase to 5% amalgamation does not interfere with the use of the spiral reductor.

The Procedure in the Use of the Spiral Zinc Wire Jones Reductor

The spiral zinc wire Jones reductor is employed as follows: the sulfate solution of ferric iron in 5–10% sulfuric acid solution and of normality from 0.01 to 0.03 in iron and of approximately 200 cc. volume is placed in a 300-cc. Erlenmeyer flask, the zinc spiral introduced and the flask covered by an inverted crucible cover, and brought just to the boiling point and allowed to digest at just the point of faint ebullition. As soon as the ferric ion color of the solution has disappeared, the heat is maintained during an interval of 15 minutes and the sample rapidly cooled to room temperature with the zinc spiral still in the solution. The spiral is then removed from the flask, washed with a generous stream from the wash bottle, allowing the washings from the coil to return to the flask. The solution is then treated with a few cc. of sirupy phosphoric acid and titrated with standard potassium permanganate.

Factors Associated with the Use of the Zinc Wire Spiral Reductor

A comparison of the advantages and disadvantages in the use of the spiral zinc wire reductor as substituted for the granular zinc reductor is of



Zinc Spiral Reductor — Jones Reductor

COMPARISON OF APPARATUS

interest. The simplicity of apparatus and materials both in preparation and in actual manipulation makes the use of the spiral reductor advantageous. These advantages are apparent from the above discussion by reference to the photo-reproduction of both reductor assemblies given in Figure 1. The main difference between the two methods consists in the fact that reactions of the old type of granular zinc can be carried out in the cold (*1*) and that there is a saving of time using the old process. This saving of time is unimportant as compared to the increased amount of attention required for the old method. By the use of the zinc spiral reductor any number of reductions can be carried out at the same time with no increase in required attention. This is by no means the case using the old process. The separation of the solution for titration is much more conveniently carried out using the spiral reductor which offsets its disadvantage of being slower in reaction than the amalgamated granular zinc, which has a much higher surface of reaction per unit weight.

The variables in the use of the spiral zinc wire reductor covered in the present discussion are: the time, temperature, acidity, and their relation to the efficiency obtained in the ratio of zinc dissolved as compared to the amount of iron reduced. The factors, temperature and acidity, were easily disposed of by selecting the boiling temperature and using the same acidity (5–10% by vol. conc. H_2SO_4) as that ordinarily employed with granular zinc reductors.

The time and efficiency factors together with the accuracy attained are given in Table II. Solutions of ferric sulfate were analyzed using the old type of reductor following the directions of Lundell and Knowles (*1*) with $KMnO_4$ as the standard solution. The latter was standardized using pure sodium oxalate in the usual manner.

TABLE II

The Use of the Spiral Zinc Wire Jones Reductor in the Determination of Iron

$Fe_2(SO_4)_3$ solution = 0.1227 *N* and 25.00 cc. of this solution diluted to 200 cc. for each experiment.

Acidity, % H_2SO_4	*Wt. Fe Taken, g.*	*Zn Loss, g.*	*Efficiency, %*	*Wt. Fe Found, g.*	*Error, g. Fe*	*Amalgamation of Zn, %*
4	0.1713	0.319	31	0.1689	−0.0024	1
5	0.1713	0.150	60	0.1703	−0.0010	2
6	0.1713	0.139	72	0.1713	±0.0000	1
7	0.1713	0.148	69	0.1715	−0.0002	2
8	0.1713	0.198	51	0.1713	±0.0000	1
9	0.1713	0.186	54	0.1713	±0.0000	1
10	0.1713	0.191	52	0.1711	−0.0003	1

From an examination of Table II it is observed that for best results an amalgamation of approximately 1% and an acid composition of 6–10% by volume concentrated H_2SO_4 are used. The highest efficiency is obtained using a 6–7% acidity. Low results are obtained for a 30-minute reduction period if the acid concentration is 5% or less. Further tests with the study of the time variable are found in Table III.

TABLE III

The Influence of Time of Reaction on the Efficiency of the Spiral Zinc Wire Reductor

25.00 cc. solution No. 1 $Fe_2(SO_4)_3$ = 27.14 cc. 0.1233 *N* $KMnO_4$ = 0.1339 *N*.
25.00 cc. solution No. 2 $Fe_2(SO_4)_3$ = 45.75 cc. 0.1233 *N* $KMnO_4$ = 0.2276 *N*.
Acid concentration 5% by volume conc. H_2SO_4. Amalgamation of zinc wire 1.75%. Dilution of $Fe_2(SO_4)_3$ to 200 cc.

25.00 cc. sol. $Fe_2(SO_4)_3$	*Time for reduction to colorless, min.*	*Period of digestion, min.*	*$KMnO_4$ Required, cc.*	*Error, cc. $KMnO_4$*	*Zinc reductor efficiency, %*
Solution 1	15	20	27.12	−0.02	65
Solution 2	15	23	45.44	−0.31	58
	17	25	45.60	−0.15	59
	15	30	45.72	−0.03	56

By examination of Table III it is seen that by the use of the lowest permissible acid concentration (5% by vol. conc. H_2SO_4) a solution 0.0167 *N* in iron requires 20 minutes for reaction while one 0.0285 *N* in ferric iron requires a minimum of 30 minutes for reduction. By comparison of the data of Table II and Table III, it will be observed that the efficiency in the case of the use of 5% by volume conc. H_2SO_4 can be increased somewhat

by the use of the minimum time required for the reduction. It is probable therefore that, using an acidity of 6–7% by volume conc. H_2SO_4, the efficiency of the zinc coil would be increased roughly to 75%. Assuming that a zinc spiral reductor such as that described is to be used until half dissolved, one reductor will provide for from 100–150 ordinary determinations of iron. The amalgamation would then still be less than 5% which has been shown to be not undesirable.

Conclusion

The use of the spiral zinc wire Jones reductor serves best for the determination of iron for the obvious reason that a ferrous iron solution is stable at room temperatures in contact with atmospheric oxygen. Other uses to which the amalgamated granular zinc reductor is applicable, such as the determination of titanium, require that the reduced titanium solution be received in an excess of ferric sulfate. The reduced ferrous iron is then titrated in place of the reduced titanium which necessitates using the spiral zinc wire reductor so that the reaction be carried out at least during the last stages in an inert atmosphere. In the case of molybdenum and vanadium this requirement, while not as necessary, nevertheless cannot be entirely avoided. The use of the spiral wire reductor may, therefore, be shown of service as a substitute for the granulated zinc reductor but this was not attempted in the present case because of the much more general use of zinc for the reduction of iron.

Summary

1. A study has been made of the use of readily available pure commercial sources of zinc in the form of wire as a convenient substitute for the familiar granulated zinc Jones reductor.

2. The preparation and amalgamation of the spiral zinc wire reductor is described.

3. The comparative advantages and disadvantages in the use of the zinc wire as a substitute for the use of granular zinc have been discussed.

4. The use of the spiral zinc wire reductor has been demonstrated and the determination of its reducing efficiency made.

Literature Cited

(*1*) LUNDELL and KNOWLES, *Ind. Eng. Chem.*, **16**, 723 (1924); *J. Am. Chem. Soc.*, **45**, 2620 (1923).

Liquid Air Compressor of Sir Wm. Ramsay. Liquid air compressor used by the late Sir William Ramsay from 1898 onward for the investigation of the rarer inert gases in the atmosphere has been placed by the authorities of University College, London, on permanent loan at the Science Museum, South Kensington.—*Chem. Age*

A CONVENIENT SYSTEM OF WATER THERMOSTATS FOR LABORATORY INSTRUCTION*

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There have been described in the existing literature a number of automatically controlled constant-temperature baths. In many cases these have been designed for high precision work where variations of not more than one- or two-thousandths of a degree were required. Such instruments can also be had commercially but like all precision instruments are exceedingly expensive. On the other hand, many devices for controlling bath temperatures have been proposed which do not work satisfactorily for any great length of time or require so much care and attention that their operation practically amounts to hand regulation of the bath.

For use in a laboratory devoted to teaching general physical chemistry the following requirements of an automatically controlled temperature bath may be enumerated:

1. *Constancy of temperature to within a few hundredths of a degree.* Extreme precision of control is not necessary but since many of the properties to be measured change appreciably with temperature, this must be kept sufficiently constant so that errors introduced by temperature fluctuation are reduced at least equal to, or below, the precision of the least precise measurements. For example, quite a number of properties vary as much as 2% per degree. Fluctuation of ± 0.05°C. might produce uncertainties in the measured value of $\pm 0.1\%$. While it is generally true that a precision of 0.1% is difficultly attainable for the ordinary student, nevertheless, since it is easily preventable, there is no need of introducing the additional error which may result from lack of temperature control.

2. *A range of temperatures is desirable.* In order to determine temperature coefficients or to show the dependence of a given property upon temperature, the bath should be easily adjusted to any desired temperature or several baths operating at different temperatures should be provided. In the system described below three baths are used, one operating at 15°C., a second at 30°C., and a third at 45°C.

3. *The bath should have transparent sides.* Since many of the measurements to be made depend upon seeing the system kept at constant temperature (such as viscosity, drop number, moving boundary measurements, etc.), it is essential that the bath be made of glass. For the best vision, flat plate glass is the most satisfactory.

4. *Operation of the bath should require the minimum attention of the instructor.* A busy instructor has sufficient demands upon his time without requiring that every day or so he take time to overhaul and readjust the regulator or other parts of the constant temperature device.

5. *Lastly the system should be as inexpensive as possible.* As remarked

* Presented before the Kansas Academy of Science, Hays, Kansas, April 18, 1930.

before, precision instruments are expensive, but by assembling individual stock pieces of equipment and employing local mechanical help the cost of such systems as those herein described can be considerably reduced. The cost of the entire system described below will be in the neighborhood of two hundred dollars for the best quality pieces. Very satisfactory equipment could be obtained at one-half to three-fourths of this estimate. Complete commercial assemblies for equipment of the capacity described below would cost between four and six hundred dollars, and would fall considerably short of some of the desirable features enumerated above.

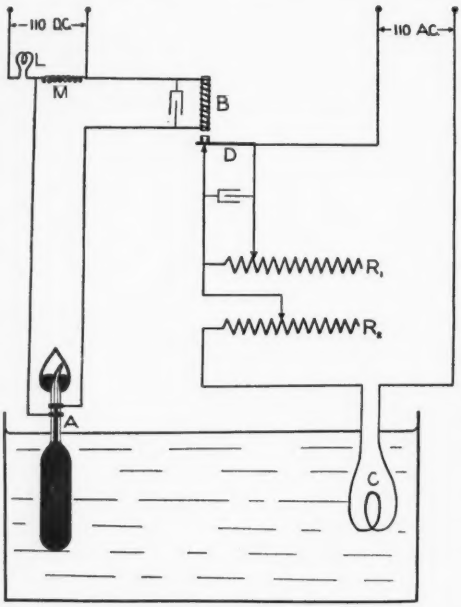

FIGURE 1.—DIAGRAMMATIC ARRANGEMENT OF APPARATUS*

A Metastatic thermoregulator
B Circuit breaker
C Heating bulb
D Circuit breaker key
L Lamp (50 watt)
M Resistance (4 ohm)
R_1 Variable resistance (200 ohm)
R_2 Variable resistance (40 ohm)

On heating, the Hg expands until it completes the circuit at A. The current magnetizes B which attracts D and throws in more resistance in the heating circuit, thereby decreasing the current in C.

On cooling, the circuit A is broken. This demagnetizes B, and D falls to its original place where it short circuits the current around R_1 and increases the current in C again.

As a result of some years' experience in the laboratory with such equipment the author has assembled the equipment described below but before starting on this description a brief outline of the method of automatically controlled temperature baths might be helpful for the less experienced.

The regulation in such systems is obtained by supplying heat to the bath (such as a glowing electric lamp) controlled by a device called the regulator. The regulator is usually a bulb filled with mercury, in the neck of which are sealed two contacts. (See Figure 1.) As the temperature of the bath rises

* Thanks are due to my colleague, Mr. Jesse Stareck, for the preparation of this drawing.

the mercury expands and eventually closes the space between the two contacts with mercury. These contacts are in the circuit of a relay and when the gap between them is filled with mercury the circuit is closed, thus bringing the relay into action. This is so arranged that it then shuts off or reduces the current in the heating circuit. The bath begins to cool, the mercury contracts, the regulator circuit is broken and the heating circuit is again brought into play. The essential features of such a bath are shown in Figure 1.

A description of the component parts of the system as we have assembled them follows.

The Baths

These are fish aquaria having dimensions 30″ × 12″ × 12″.* They have plate glass sides mounted in steel-enameled frame with a suitable cement. This cement begins to soften at temperatures in the neighborhood of 45°C. so that it is not advisable to operate them above this temperature. As we employ them there are three baths placed end to end, thus occupying a table space approximately 8 feet long. Mounted on the wall behind these baths is a shaft turned by a motor. The stirrers for each bath are operated by belts and pulleys from this common shaft. The relays, resistances, etc., are all placed in a cupboard beneath the table and locked to prevent students tinkering with them. In order that an understanding of the operation of the baths may be conveniently obtained by the interested students, an enlargement of Figure 1 has been framed and placed on the wall behind the baths. The baths are placed on benches 6″ high which serve the purpose of elevating the baths so that observations are more easily made and also because the clear space beneath the benches is required to place the bases of stands used to support equipment and apparatus placed within the baths.

The Bath Liquid

Distilled water must, of course, be used for the bath liquid, as the continued evaporation would leave considerable residue if tap water were used. We have not attempted to fit the baths with constant-level devices but have formed the habit of filling them each morning as the loss, even in the one operating at 45°C., is not more than several liters. Another constant source of annoyance in connection with the bath water is the growth of mold, soon producing a cloudy bath, although the 45° bath is free from this growth. We have added a number of substances to prevent this growth, *e. g.*, chloroform, phenol, mercuric chloride, and copper sulfate. Of these copper sulfate appears to be the most effective. If copper sulfate is used care must be taken that all iron surfaces are thoroughly protected with

*Obtainable from the Central Scientific Co., Chicago.

enamel or lacquer. One of the defects of using copper sulfate is that it makes the bath an electrical conductor and therefore a possible source of leakage if electrical measurements are made. It will be recalled that in precise electrical measurements oils are almost invariably used as bath liquids.

Heaters

As heaters we have employed (*a*) ordinary electric lamps, (*b*) electric lamps known as radiant heaters,* (*c*) a metallic knife type immersion heater,** and (*d*) a flexible metal-cased heating coil.† Of these we prefer types (*a*) and (*b*) as their heat capacities are apparently less than the other types of heaters and therefore they do not continue to add heat to the bath after the current is shut off. Types (*c*) and particularly (*d*) are useful as the space taken up in the bath is considerably less than that required for the lamps. Type (*d*) may be bent in any shape desired and can therefore be placed along the side and bottom of the bath, thus taking the minimum of space. These types of heaters are also useful where the emission of light would prove harmful to the system under observation. We have found it advisable to choose a heater of somewhat greater capacity than demanded by the size of the bath in order to make them usable over a considerable range of temperature. For the baths described here a 250-watt radiant type heater is employed. This is not used at its full rating, as the current flowing through it is regulated by an external resistance placed in series with it. (*Cf.* Figure 1.) In order to secure a greater uniformity of temperature throughout the bath, two lamps in parallel‡ are generally used at opposite ends of the bath. The bath operating at 15°C. is always below room temperature and therefore removal of heat is required. As the automatic control of heat removal is more difficult than that of heat addition, it is customary to cool the bath somewhat lower than required and obtain the constancy of temperature by the control of a heating circuit as above described. We obtain the cooling by passing tap water through three coils of 3–8″ thin copper tubing placed at the top and inside of the bath, *i. e.*, in the bath liquid itself. We have not had occasion to use this bath when the tap water rises above 15°C., but are planning on precooling the water before it passes through the bath by immersing a portion of the copper tubing in a large porcelain jar filled with ice placed between the tap and the bath.

* Obtainable from Westinghouse Electric Co., East Pittsburgh, Pa. Style No. 102,747.

** Obtainable from Central Scientific Co., Chicago.

† Obtainable from General Electric Co., Schenectady, N. Y. Trade name "Helicoil" units.

‡ Putting them in series with each other reduces the current to such an extent that the I^2R value is insufficient to keep the bath at the higher temperatures.

Regulators

As regulators we have employed a commercial form known as the Metastatic Thermoregulator.* This is illustrated diagrammatically at *A* in Figure 1. The chief advantages of this type of regulator over the more familiar forms of mercury or mercury-toluene regulator are (*a*) adjustability over a wide range of temperatures and (*b*) absence of oxygen (air) within the system. As shown in the diagram, there is a reservoir for excess mercury in the upper bulb, *i. e.*, the amount of mercury in the regulator proper can be varied and hence be used over a range of temperatures. For use at a higher temperature than that for which it is originally set it is necessary to warm it slightly above the temperature desired, thus expelling mercury from the regulator into the upper reservoir. For use at a lower temperature, the regulator is inclined until the capillary in the upper reservoir is beneath the mercury and the bulb of the regulator is then warmed until the mercury in the capillary makes contact with that in the reservoir, the bulb then being slowly cooled to slightly above the desired temperature. The regulator is then returned to its vertical position. The slight elevation of temperature above that desired for each setting may be determined approximately as follows: assume that the regulator has been set for 45°C. and it is desired to set it at 30°C. Mercury is drawn from the reservoir as described above by placing the regulator in water at 30°C. When the regulator has reached this temperature it is turned into a vertical position and a small drop of mercury clinging to the end of the reservoir is shaken off into the reservoir. Cooling is then continued further until contact is broken between the upper platinum contact and the mercury meniscus; breaking being detected by the relay and not visually. The temperature at the break is then noted; let us say in this case it was 29.10°C. The difference in temperature, *i. e.*, 30–29.1° or 0.9°, is the constant of the instrument. That is the temperature at which the drop was shaken off should have been 30.9° in order to obtain regulation at 30°. This constant can be used for any subsequent setting. Setting to an exact temperature requires a number of trials.

These regulators can be obtained in several sizes—we employ for these baths an 8″ size. The sensitiveness, *i. e.*, the length of the temperature interval between make and break, will depend upon the total volume of the mercury and the diameter of the capillary portion of the regulator, greater sensitivity being secured by a large volume and area of mercury and a small capillary. We have noticed considerable difference in the diameter of the capillary for the same sized bulb. For work where the greatest precision obtainable is desired the smallest size of capillary should be chosen.

* Obtainable from American Instrument Co., 774 Girard St., N. W., Washington, D. C., or Hiergesell Brothers, 2518 N. Broad St., Philadelphia.

The second advantage mentioned for these regulators was the absence of air. The greatest defect of the open-to-air type of mercury regulator lay in the fact that at the break of the regulator circuit the current, due to its inertia, continued on across the small air gap, producing a spark. This continued sparking produced mercury oxide which contaminated the surface of the mercury and interfered with good electrical contact as the mercury rose in the capillary. Consequently to obtain any pretense of precise temperature control required frequent cleaning and resetting of the regulator. In the metastatic type of regulator air is removed and hydrogen substituted. The oxide formation is thus prevented and further hydrogen has the effect of damping the electric spark. After continued use for some nine months several of our regulators have had to be replaced, due to the fact that the mercury in the capillary would separate during the cooling period. We ascribed this to slight oxide formation (due to incomplete removal of air) on the walls of the glass in the capillary which caused the sticking of a small fragment of mercury as the mercury descended the capillary, thus producing an uncertainty in the setting.

Sparking can be considerably reduced by making the current in the regulator circuit as small as possible and by placing a condenser in parallel with the two contacts of the regulator as shown in Figure 1. As a matter of theory it should be possible by the choice of a condenser of suitable capacity to completely eliminate sparking; actually it is rather difficult to do so. If the capacity of the condenser is too small it will not "absorb" all of the electricity which would pass in the spark; if it is too large sparking occurs on "make," producing still more serious troubles. We have explained this last effect as due to the discharge of the condenser just before "make" across a very small air gap; the current from the condenser is added to that coming from the applied potential, thus increasing the current momentarily with the result that the mercury surface is actually moved. Making and breaking may occur several times before the current steadies down. There is thus an optimum value for the capacity of the condenser and this can only be found by trial and error. Those we have employed are telephone condensers having a capacity of 2 microfarads.

Another remedy suggests itself. Most of the relays we have employed function only on direct current. A specially wound relay to operate on alternating current would diminish the sparking very materially.

Relays or Circuit Breakers

In the older types of automatic temperature regulation a telegraph relay was used to make and break the heating circuit as we have shown in Figure 1. The contact points at which the heating circuit was made and broken, as in the regulating circuit, were always a source of grief. The current being larger in this circuit caused continual corrosion or sticking of the

points of contact which were made of metal or of carbon. The recent introduction of commercial mercury circuit breakers has solved very largely this problem. We have tried two types of these circuit breakers. In one type* a small cylinder of soft iron rises and falls by magnetic attraction in a glass tube filled with mercury. This in turn causes the mercury to fall and rise in a U-shaped limb. Two tungsten contacts are sealed through at the two ends of the U and these are placed in series with the heating circuit. As the mercury falls in the U the circuit is broken and when it again rises the circuit is closed, making and breaking of the circuit taking place in an air-free atmosphere. The iron cylinder is actuated by a solenoid placed externally about the glass tube containing it. This solenoid is in series with the regulating circuits; when the regulating circuit is closed the solenoid produces a magnetic field sufficient to cause the iron cylinder to rise, which shuts off the heating circuit as above described. When the regulating circuit is open the iron core drops down.

The second form** of circuit breaker employed resembles the familiar telegraph relay more closely. It consists of "a cylindrical glass tube partly filled with mercury and having two non-deteriorating electrical contacts sealed into one end. The tube is exhausted and filled with an inert gas which serves to prevent oxidation of the contacts and mercury and tends to prevent any tendency toward arcing. The tube is mounted in a saddle at a slight angle to the horizontal so that the mercury runs to the end of the tube, which carries the contacts. Upon energizing the relay the tube is tilted so that the mercury flows to the other end of the tube, thus disconnecting the contacts and cutting off the current." Both types of circuit breakers have their advantages. The first type operates on a current of 70 milliamperes whereas the second requires about a third of an ampere, the last type thereby considerably increasing the sparking in the regulator described above. On the other hand, the second type operates more rapidly than does the first, producing no appreciable time lag in the control of temperature, and for that reason we have more generally employed this type.

The first type may be operated directly on 110 a. c. or 110 d. c. but we have added sufficient resistance in series with it to reduce the current to its lowest operating value. The second type requires about 2 volts d. c. We have obtained this by the potential divider arrangement shown at L and M in Figure 1. Of course dry cells could be used for its operation.

Stirring

The constancy of temperature throughout the bath depends largely upon the rate of stirring; the greater the rate of stirring the more nearly will

* Obtainable from Westinghouse Elec. Co., Style No. 352,397.

** Obtainable from the American Ins. Co.

the temperature be constant throughout the bath. The upper limit of speed must be such that water is not thrown out of the bath or that the water moves so rapidly as to disturb apparatus placed within the bath. Our stirrers consist of a brass shaft 3–8″ in diameter and 14″ long rotating in a hollow brass sleeve 5–8″ in diameter and some nine inches in length. Such a sleeve can be held in a clamp and is practically free from vibration. The two bearings at each end of the sleeve are of hard wood rather than metal as we have found that metal bearings soon cut the shaft at the lower end. Wooden bearings will last for years. The lower one should be drilled somewhat large to take care of the expansion of wood in water. A wooden pulley is glued to the upper end of the shaft. Several grooves of different diameter are cut in the pulley to allow some variation of the speed of rotation. A four bladed propeller cut from sheet copper of approximately $3^1/_2$″ diameter is mounted on the lower end by threading the end to take a small bolt. By the use of two washers the blades may be firmly held.

Such a stirrer is centrally placed in the bath, the blades being near the bottom. The blades should be bent and the direction of rotation should be such as to produce a downward current of bath liquid at its center, but a spreading and rising current at the sides. An upward current at the center would tend to produce greater differences of temperature between the upper center of the bath and the bottom or sides due to the natural tendency of the water in contact with the heater to rise.

The rate of stirring is about 300 revolutions per minute, although this is increased in the bath operating at 45°C. To secure this rate we have used a slow-speed d. c. motor operating at 400 r. p. m. Such motors are not stock items and ours have been made to our specifications.* Stock motors usually operate on a. c., at 1700 to 1800 r. p. m. As this rate is entirely unnecessary and as our motors are employed continuously for long periods, some running without stop for eleven months out of the year, it was thought best to employ the slower speed d. c. motors described above. With frequent oiling and occasional cleaning of contacts such motors have lasted for years.

As stated before, but one motor is used to operate a counter shaft from which all three baths are stirred.

Electrical Circuits

Some of the essential features of the electrical circuits have already been discussed and are fully diagrammed in Figure 1. It will be noted that a condenser is also placed in parallel across the heating circuit for the same reason that it was employed in the regulating circuit. It might be worthwhile to call attention to the fact that the two circuits are entirely independent of each other. The reader has doubtless noted this already as we

* These are 1–20 h. p. built by the Robbins and Meyers Co., Springfield, Ohio.

have employed the terms "regulating circuit" and "heating circuit" considerably. As will be seen, the heating circuit operates on 110 a. c., the regulating circuit on 110 d. c.

An examination of the circuit including R_1 and R_2 and a consideration of the legend included in Figure 1 shows that the heating current is not completely shut off when the regulating circuit is complete, but that the introduction of more resistance simply reduces the current flowing through the heater. Such an arrangement produces smaller fluctuations of temperatures than when the current is completely shut off. The connections shown in the heating circuit have been somewhat modified from that usually recommended, by altering the position of the sliding contact on R_2. With the arrangement as shown it is possible to alter the position of the contact on R_1 without causing a compensating change in the contact on R_2, *i. e.*, the current during the cooling period may be adjusted to any desired value while the current during the heating period remains constant. This arrangement is especially helpful where room temperatures fluctuate and readjustment of current thus becomes necessary. The resistances R_1 and R_2 are the familiar variable rheostats of nichrome wire mounted on a porcelain-covered steel tube. These can be obtained from a number of scientific supply houses.

Performance

These baths will run for weeks at a time with very little attention. If the room temperatures fluctuate considerably adjustment of the heating current is necessary by altering the values of R_1, and when the temperature falls considerably, of R_2. When the heating current is once adjusted to a suitable value, the temperature of the bath remains quite constant. A Beckmann thermometer placed in the 30° bath and observed shortly after the end of each heating and cooling period for over a period of several hours showed a maximum variation of 0.02°C., that is, the temperature of the bath was 30.00° ± 0.01°. For the baths operating considerably above and below room temperature the fluctuations were ±0.03° from the set value.

It would be possible by taking greater care in the adjustment of the heating current, by reducing the cooling rate (*i. e.*, surrounding the bath, save for an observation opening, with a heat insulator) to increase considerably the precision of control, but we have felt that the values obtained were sufficient for our purpose.

Cost

An estimate of the cost of the equipment is given below. This does not include cost of heaters, or of employment of help in mounting. The heaters cost from 45 cents for a 150-watt Mazda lamp to somewhat over five dollars for the knife type heaters.

3 Aquaria	at $24.00	$ 72.00
1 Motor		35.00
3 Regulators	at 10.00	30.00
3 Relays	at 12.00	36.00
6 Resistances	at 6.00	36.00
3 Stirrers	at 1.00	3.00
Total for three baths		$212.00

As stated previously, this cost could be considerably reduced. Cheaper types of baths are easily obtainable; an a. c. motor could be used and geared down, homemade resistances could be employed, but when the instructor's time and the results are considered the above combinations are, in our experience, the most satisfactory yet found.

Jubilee Exhibition of Bohemian Glass. The Bohemian glass industry was founded in the 17th century and rapidly attained to some importance in the Iser and Sazava valleys. There is now in progress at Zelezny Brod, one of the chief centers of the Czechoslovak glass industry, an exhibition of glassware. The chemical glassware, a familiar product in all laboratories, comes chiefly from Sazava where wood is still partly used as fuel. An idea of the extent of the industry may be gathered from the production figures for blown glass:

Year	*Tons*	*Value in thousand crowns*
1922	41,186	403,106
1923	37,197	327,945
1924	51,408	430,661
1925	58,153	527,657
1926	56,188	501,560
1927	60,593	518,615
1928	68,756	571,592
1929	68,713	583,192

The figures for plate glass are also rising annually, while in addition there is a considerable output of fancy glassware at Jablonec (Gablonz).

The production of plate glass is given in the following table:

Year	*Tons*	*Value in thousand crowns*
1922	32,617	107,023
1923	28,745	71,080
1924	44,074	97,662
1925	50,346	120,946
1926	50,672	135,107
1927	56,706	150,906
1928	69,888	182,617
1929	87,046	221,706

—*Chem. News*

A FORM OF CONDENSER FOR USE WITH HIGH-BOILING-POINT LIQUIDS

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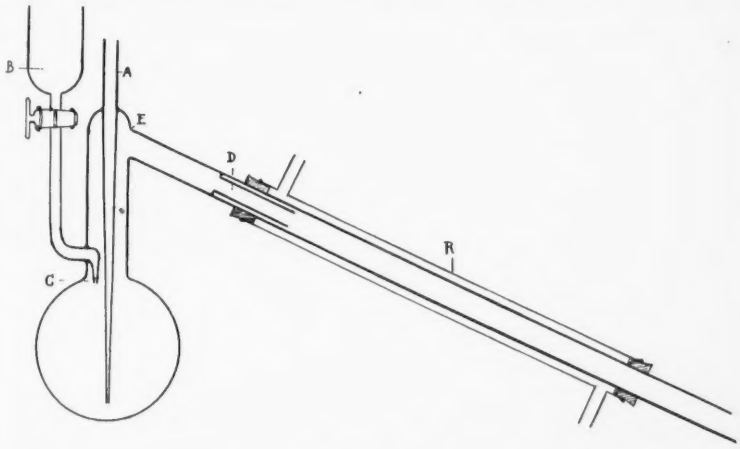
For purposes of purification of mercury, a still was required which, while simple in construction, would yet have a high rate of distillation. It had been observed that mercury in a glass condensation pump distilled over rapidly, and the still described below was then constructed on the same principles as a simple condensation pump. The apparatus has since been found of use in the distillation of high-boiling-point liquids under vacuum.

Description of Apparatus

Constructed of Pyrex glass, the air inlet *A* was first sealed into a 100 cc. round-bottomed flask. The tube *A* consisted of a piece of 5-mm. bore



tubing drawn out to a capillary. The tap-funnel *B* was then sealed in, the inside end of the tube *C* being drawn out to form a dropper so that the entering cold liquid did not touch the hot sides of the flask. A jet *D*, 5 cm. long and of 5 mm. bore, was fused into a length of 10 mm. bore tubing, at a distance of 10 to 15 cm. from one end *E*, which was then sealed into the neck of the flask just below the seal *A*. A water jacket was then attached as shown in the diagram. Asbestos string was wound on the boiler and as far as the jet on the condenser *R*.

By means of the tap-funnel *B*, 30 to 40 cc. of liquid was introduced into the flask and a vacuum was produced at the receiving end of the apparatus. The amount of air allowed to bubble in through the tube *A* was controlled by means of a screw clip on a short piece of rubber tubing. For compara-

tive purposes an exactly similar piece of apparatus was constructed, but without the jet.

It had been observed, that when a mercury condensation pump was in operation, the level of the mercury in the return pipe was considerably higher than that of the mercury within the boiler. In order to record any changes of pressure within the apparatus described above, vacuum pressure gages were connected, G' to the tap-funnel B, G'' to the pump end of the condenser.

Experimental Data

Distillations were carried out under known conditions of temperature and pressure, using liquids of various boiling points.

In each distillation using the apparatus with the jet, an increase of pressure in the boiler was recorded by the pressure gage G', while in no case was such increase of pressure observed using the apparatus without the jet. Since no comparison of rates of distillation could be made unless the liquids boiled at the same temperature in both forms of apparatus, it was so arranged that the pressure in the boiler of the apparatus without the jet was the same as that in the boiler of the apparatus with the jet, and the temperature of the bath was kept constant in both cases.

Ethyl Malonate: *Boiling Point* 198°C. (at atmospheric pressure).

The increase of pressure in the boiler of the apparatus with the jet was found to be 3 mm. of mercury on boiling with the bath at a temperature of 160°C. The yield of distillate from the apparatus without the jet was almost as great as that from the apparatus with the jet.

Nitro-benzene: *Boiling Point* 207°C. (at atmospheric pressure).

The increase of pressure in the boiler of the apparatus with the jet was found to be 3.5 mm. with the bath at a temperature of 180°C. The yield of distillate from the apparatus without the jet was 85% of that from the apparatus with the jet.

Glycerin: *Boiling Point* 290°C. (at atmospheric pressure).

The increase of pressure in the boiler of the apparatus with the jet was found to be 4 mm. with the bath at a temperature of 240°C. The yield of distillate from the apparatus without the jet was 80% of that from the apparatus with the jet.

Mercury: *Boiling Point* 357°C. (at atmospheric pressure).

The increase in the boiler pressure of the apparatus with the jet was found to be 7.5 mm. with a bath temperature of 260°C. The yield of distillate from the apparatus without the jet was 55% of that from the apparatus with the jet.

An experiment was carried out using the apparatus without the jet, the vacuum attained in the boiler being the greatest obtainable with the pump used, *i. e.*, the boiler pressure in this case was 7.5 mm. less than that in the apparatus with the jet. It was then found that the yield of distillate was 75% of that obtained in the case of the apparatus with the jet. Trouble was, however, experienced with the burning of stoppers on the apparatus without the jet.

It has been shown that with the lower-boiling liquids, little is gained by use of a jet in the condenser. In the case of liquids boiling above 200°C.

an increased speed of distillation is obtained while owing to the construction of the condenser with the jet, water cooling can be used.

It is thought that the increased speed of distillation is due to two factors. The constriction of the outlet from the boiler caused by introducing the jet causes an increase of pressure in the boiler, which forces the vapor through to the condenser at a greater velocity. This vapor shooting through the jet acts in the same way as in a condensation pump and a vacuum is created in the space around the jet, thus tending to draw the vapor through at a higher speed.

Gas. William Murdoch ran a small experimental gas plant in 1795, lighted a Soho factory by gas a few years later, and in 1808 was awarded the Rumford Medal of the Royal Society for his invention. The Gas Light and Coke Company was incorporated in 1812. In Baltimore, gas lighting got its start in the United States on June 17, 1816, when the city council passed an ordinance permitting Rembrandt Peale not only to continue lighting his museum by gas but to manufacture gas in quantities, lay pipes in the streets, and contract with the city for street lighting. [*Cf.* J. CHEM. EDUC., 6, 738–44 (Apr., 1929).]

Electricity's advent, sixty years or so later, spelled the doom of lighting revenues to the gas industry, although temporary relief came about through securing most of the urban cooking load of the country. But, compared to other utilities, the gas people slumbered for years, notable for their unwillingness to adopt progressive practices. However, what has been accomplished since 1900 and, most strikingly in the natural gas industry, within a decade, points to an encouraging future. Sales of manufactured gas in this country have mounted annually for 25 years to quadruple what they were, but natural gas production has moved from 662,000 million cubic feet in 1921 to 2,000,000 in 1929.

Creation of new uses for gas in mechanical refrigeration, for domestic heating of houses and apartments, and in manifold industrial operations, accounts for acceleration of demand. Intercommunication of small plants to eliminate wasteful and obsolete producers, cutting down overhead and obtaining diversity of load, and the transportation of gas under compression through long distance pipelines, have made it possible to keep pace with the demand. . . . .

Trunk and subsidiary pipelines in the United States now total nearly 200,000 miles, the longest present transmission being from the Louisiana fields to Birmingham, Alabama, and Atlanta, Georgia, 468 miles. . . . .

From the Monroe-Richland field of Louisiana natural gas is now being pumped 447 miles to St. Louis, crossing 15 rivers on the way. . . . .

Present lines are from 14 to 24 inches in diameter and the development of steel pipe has made them capable of withstanding 300 to 600 pounds per square inch pressure. Improvements in manufacturing, laying methods, and ways of preventing corrosion make it possible that pipelines can now be constructed for less money than electrical transmission lines of equivalent energy capacity. The effect on public health can be imagined when it is estimated that smoke and soot are now accountable for a deposit of 460 tons annually on a square mile in Chicago. . . .—*Tech. Rev.*, **32**, 445 (July, 1930)

DOCTORATES IN CHEMISTRY AND RELATED FIELDS CONFERRED BY AMERICAN UNIVERSITIES, 1929–1930

COMPILED BY CLARENCE J. WEST AND CALLIE HULL, RESEARCH INFORMATION SERVICE, NATIONAL RESEARCH COUNCIL, WASHINGTON, D. C.

The Research Information Service of the National Research Council again offers the following statistics concerning the doctorates in chemistry and related fields conferred by American Universities during the academic year 1929–1930. This is the sixth year in which this compilation has been made; previous lists have been published in the JOURNAL OF CHEMICAL EDUCATION **3,** 77–99 (Jan., 1926); **4,** 99–109 (Jan., 1927); **4,** 1303–13 (Oct., 1927); **5,** 1450–63 (Nov., 1928); **6,** 2209–23 (Dec., 1929).

In this compilation the doctorates granted by the universities in agricultural chemistry, biochemistry, engineering, and metallurgy have been listed under the separate headings but are included in the totals by university in the statistical tables. In selecting the titles to be included, those doctorates have been used, which, if published, would probably be abstracted in *Chemical Abstracts*. Attention is again called to the fact that the compilers have only the title of the thesis and, in most instances, the department in which the doctorate was granted, to aid them in the subject classification. It is not always possible to classify correctly from this information, which may account for the inclusion or the omission of a given thesis. Corrections and suggestions as to this publication are always appreciated.

There are fifteen universities who report ten or more doctorates in chemistry and related subjects during the past academic year. Chicago assumes first place this year with 37 doctorates; Wisconsin, first in the past two compilations, assumes second place; Yale and Illinois tie for third place.

Information concerning all the doctorates granted in the sciences (1055 for the year 1929–1930) will appear in a forthcoming number of the Reprint and Circular Series of the National Research Council, copies of which may be obtained from the Publication Office.

TABLE I

Distribution of Doctorates in Chemistry by University, by Year

Institution	'21–'22	'22–'23	'23–'24	'24–'25	'25–'26	'26–'27	'27–'28	'28–'29	'29–'30
American	..	..	..	..	1	1	1	..	3
Boston	..	1	..	..	1	..	..	..	1
Brown	..	..	..	5	2	2	4	4	6
Bryn Mawr	1	..	..	..	..	1	..	1	..
California	8	11	6	8	7	16	9	13	15
Calif. Inst. Tech.	2	..	3	4	7	..	6	4	4
Catholic	..	1	2	2	1	3	1	2	1
Chicago	14	12	19	14	26	21	19	24	37
Cincinnati	3	1	2	4	4	3	..	8	4
Clark	2	3	3	..	..	..	..	..	..
Colorado	1	1	..	1	2	1	3	3	..

TABLE I (*Concluded*)

Institution	'21–'22	'22–'23	'23–'24	'24–'25	'25–'26	'26–'27	'27–'28	'28–'29	'29–'30
Columbia	13	28	35	30	34	28	23	25	18
Cornell	9	8	19	14	12	16	21	15	15
Duke	..	..	..	..	..	..	..	4	2
Fordham	2	2	..	2	2	1	2	8	4
Geo. Washington	..	6	3	1	2	2	1	3	..
Harvard	3	5	18	13	10	11	8	7	8
Illinois	16	19	19	18	18	11	16	16	24
Indiana	1	2	1	2	2	2	2	3	3
Iowa	..	4	3	6	10	9	16	13	12
Iowa State	..	..	4	7	8	7	13	13	12
Johns Hopkins	13	12	12	10	19	15	17	21	21
Kansas	..	..	1	3	1	5	3	5	5
Maryland	..	..	..	..	4	2	3	2	2
Mass. Agr. Coll	..	1	..	..	..	..	..	..	..
Mass. Inst. Tech	5	6	11	17	8	6	7	11	12
Michigan	5	2	11	2	13	8	8	13	15
Mich. State Coll	..	..	..	..	1	..	..	..	1
Minnesota	5	3	9	8	8	8	19	15	16
Missouri	..	..	1	1	1	1	2	1	1
Nebraska	1	1	3	3	1	1	..	1	2
New York	1	6	1	3	2	3	6	4	7
N. Y. State Coll. For	..	..	..	..	..	..	1	..	..
North Carolina	1	1	..	..	5	2	4	2	1
Northwestern	4	..	4	1	1	3	5	3	7
Notre Dame	..	1	2	..	..	..	..	1	3
Ohio State	4	13	14	23	11	15	13	19	22
Pennsylvania	3	..	4	1	7	7	3	3	7
Penna. State	..	..	..	..	..	..	4	3	3
Pittsburgh	5	6	5	7	3	10	9	7	11
Princeton	5	2	8	4	4	4	8	7	5
Purdue	..	..	..	..	..	..	..	..	2
Radcliffe	..	..	..	..	..	..	1	1	..
Rensselaer	..	..	..	..	..	..	3	1	1
Rice	..	..	..	1	..	1	1	1	2
Rochester	..	..	..	1	..	2	3	..	2
Rutgers	..	..	..	..	..	..	1	3	5
St. Louis Univ	..	..	..	..	..	2	1	1	1
Stanford	1	3	8	2	5	3	3	9	8
Syracuse	..	..	..	..	..	2	1	..	2
Texas	..	..	..	..	..	..	..	..	1
Tulane	..	..	..	..	..	1	..	..	..
Virginia	1	1	2	3	2	3	2	3	4
Wash. U., St. Louis	..	1	..	..	..	2	..	2	1
Washington	2	..	1	2	..	1	1	4	2
Western Reserve	..	..	..	..	..	..	..	..	3
Wisconsin	13	14	21	26	24	16	25	31	27
Yale	13	17	8	16	18	12	19	19	24
TOTAL	157	194	263	265	287	270	300	359	394

TABLE II

Universities Granting 10 or More Doctorates in Chemistry, 1929–1930

Institution	'21–'22	'22–'23	'23–'24	'24–'25	'25–'26	'26–'27	'27–'28	'28–'29	'29–'30
Chicago	14	12	19	14	26	21	19	24	37
Wisconsin	13	14	21	26	24	16	25	31	27
Illinois	16	19	19	18	18	11	16	16	24
Yale	13	17	8	16	18	12	19	19	24
Ohio State	4	13	14	23	11	15	11	19	22
Johns Hopkins	13	12	12	10	19	15	17	21	21
Columbia	13	28	35	30	34	28	23	25	18
Minnesota	5	3	9	8	8	8	15	15	16
California	8	11	6	8	7	16	9	13	15
Cornell	9	8	19	14	12	16	21	15	15
Michigan	5	2	11	2	13	8	8	13	15
Iowa	..	4	3	6	10	9	16	13	12
Iowa State	..	..	4	7	8	7	13	13	12
Mass. Inst. Tech	5	6	11	17	8	6	7	11	12
Pittsburgh	5	6	5	7	3	10	9	7	11

CHEMISTRY

American University

GEORGE RICHARD GREENBANK, "The Oxidation of Fats and Oils." JAMES IRVIN HOFFMAN, "Fluorine and Its Determination." GEORGE PATRICK SANDERS, "Calcium, Phosphorus, and Magnesium in Milk."

Boston University

WILLIAM CLOUSER BOYD, "A New Series of Halogenated Sulphonephthaleins."

Brown University

EDWARD ALISON FLOOD, "Some Ethylgermanium Derivatives." WILLIAM WISNER HAWES, "The Properties of Certain Amide Ions as a Function of Their Constitution." WILLIAM HARLOW KAHLER, "The Electrical Conductivity of Solutions of Sodium Triphenylstannide and Analogous Salts in Liquid Ammonia." WALTER KENNETH NELSON, "Studies Relating to Organo-Silicon Derivatives. I. Triethyl Silicon Derivatives. II. Triphenyl Silicon Derivatives." HORACE BOSS PRAY, "Mutual Solubility Effects of Salts in Ethyl Alcohol."

California, University of

GEORGE HAMILTON CADY, "Some Properties of Fluorine and Hydrofluoric Acid." CARL JOSEPH CHRISTENSEN, "Transition Probabilities from the 3P State of Sodium When Excited by 3303 Å Resonance Radiation." KARL JOHN KORPI, "The Kinetics of the Decomposition of Some Quaternary Ammonium Bases." ROBERT WILBUR LAWRENCE, "I. The Magnetic Susceptibility of the Ions of Uranium in Aqueous Solution. II. The Hydrolysis Constant of Iodine." HERMAN ALFRED LIEBHAFSKY, "The Reduction of Iodate Ion by Hydrogen Peroxide." MILTON JOSEPH POLISSAR, "The Kinetics, Statics, and Energetics of the Thermal Reaction $CH_2I.CH_2I = CH_2{:}CH_2 + I_2$ in CCl_4 Solutions." EDWARD JOHN SALSTROM, "The Free Energies of Some Molten Metal Bromides and Their Solutions." JOHN PETER SERMATTEI, "The Water Gas Equilibrium." CARL VINCENT SMYTHE, "Studies on the Combination of Iron with Certain Proteins, Amino Acids, and Related Compounds." HAROLD ROBERT

STEWART, "Positive Ray Analysis of the Saturated Hydrocarbons." AARON WACHTER, "Thermodynamic Properties of Solutions of Molten Lead Chloride and Zinc Chloride."

California Institute of Technology

LEE REED BRANTLEY, "High-temperature Equilibria." DANIEL BRENT MCRAE, "Investigations on the Reflection and Transmission Characteristics of Photographic Plates." JAMES HOLMES STURDIVANT, "The Structures of the Ionic Crystals Brookite and Columbite." HOMER BIGELOW WELLMAN, "The Equilibrium between Bivalent and Quadrivalent Palladium and Chlorine in Hydrochloric Acid Solution."

Catholic University

HUGH THOMAS O'NEILL, "Rates of Reduction of Some Aromatic Nitro Compounds."

Chicago, University of

ARTHUR EDWARD BROOKS, "The Dissociation Constant of Dibasic Stereoisomeric Acids." HOUGHTON GEORGE CLAPP, "I. A Study of Organic Oxides. II. Stability of Organo Lead Derivatives." MAURICE LEON COHN, "Rearrangements of Dimethylphenylmethyldichloroamine, Dimethylphenylmethylmonochloroamine, and β-dimethylphenylmethylhydroxyamine." RUSSEL BLAUCH COOPER, "The Pinacol-pinacolone Molecular Rearrangement." MORRIS HYMAN DASKAIS, "I. A Study of Free Radicals. II. A Method for Determining the Structure of Organic Stannomic Acids and a New Method of Preparation of Organo-Mercuri Compounds." MELVIN ORVIL FOREMAN, "Electromers of 2-Pentene." CALVIN SOUTHER FULLER, "I. An Apparatus for Measuring Strong Magnetic Fields. II. The Magnetic Susceptibility of Nitric Oxide. III. The Glaser Effect." DOROTHY RUTH GASTON, "I. The Biuret Reaction of Barbituric Acid and Glycine Anhydride. II. A Summary of Methods of Synthesis of Amino Acids and Peptides." EVELYN GERTRUDE HALLIDAY, "Vegetable Pigments: Their Chemistry and Their Preservation in Cooking." DONALD HUTTON, "I. Further Studies on 2,2′-Dihydroxyisobutyric Acid and on 2,3-Dihydroxybutyric Acid. II. The Action of Bromine and Nitric Acid on Some Aliphatic Diamines. III. Attempted Reduction of Erythronic Lactone." HUBERT FAIRLESS JORDAN, "I. The Ring Method for the Determination of the Surface Tension of Liquids. II. The Entropy Principle and the Entropies of Surface Formation of Liquids." CHARLES WILLIAM LENTH, "Molecular Rearrangement of β,β-Diphenyl-β-hydroxyethylamine." EDMUND WARING LOWE, "Salts of α-Phenylbutyronitrile." CARL MAURITZ MARBERG, "Sodium Salts of Primary and Secondary Aryl-acetonitriles." FREDERICK MADISON NEIGS, "Action of Organic Halides on Alkali Metal Salts of Alcohols." JOHN GEORGE MEILER, "The Decomposition of Potassium Chlorate." ALBERT WILLIAM MEYER, "Some Physical and Thermodynamic Properties of Solutions of the Alkali Metals and of Sodium Bromide in Liquid Ammonia." MINETTE DOROTHEA NEWMAN, "Mercuration in the Triphenylmethane Series of Dyes. The Mercuration of Aurin." ISABEL TILTON NOBLE, "New Methods for the Study of Physical and Chemical Properties of the Batter and Dough Series." HUGH ALLEN SHADDUCK, "The Synthesis and Disintegration of Atoms as Revealed by the Photography of Wilson Cloud Tracks." FREDERICK CHARLES MAXTED SMITHSON, "Reactions of Hypochlorous Acid on Substituted Aromatic Amines, on Cinnamic and Crotonic Acids," WILLIAM ELIAS STURGEON, "I. A Study of the Product of the Action of Phenyl Magnesium Bromide on Propiophenone Oxime: 1,1-Diphenyl-1-hydroxy-2-aminopropane, $(C_6H_5)_2C(OH)CH(NH_2)CH_3$. II. A Further Study of the Product of the Action of Phenyl Magnesium Bromide on Acetophenone Oxime: 1,1-Diphenyl-1-hydroxy-2-aminoethane, $(C_6H_5)_2C(OH)CH_2NH_2$." HAROLD HERBERT TUCKER, "2-Chloro-3′-bromoindophenol."

HORACE BULLE VAN VALKENBURGH, "I. Ferrous Nitroso Compounds. II. The Structure of Ferric Thiocyanate and the Thiocyanate Test for Iron." WILLIAM EUGENE VAUGHAN, "The Quantum Efficiency of Ozone Formation in the Fluorite Region." OLIVER GEORGE VOGEL, "The Relative Partial Molal Heat Contents of the Constituents of Aqueous Sodium Chloride Solutions." ADDISON CAMPBELL WHEATLEY, "The Preparation and Some Properties of the Sulfides of Germanium."

Cincinnati, University of

ALFRED JOSEPH BERGER, "The Electrical Conductance of Aqueous Solutions of Cobalt Sulfate." ELMER GEORGE GERWE, "The Autoxidizability of Pure Cysteine and the Action of Cyanides." HOKE SMITH GREENE, "Quantitative Determinations with the Centrifuge and Factors Affecting Them." JOHN HOWARD PAYNE, "The Mechanism of the Action of Hydrogen Peroxide upon Simple Carbon Compounds."

Columbia University

MABEL E. BALDWIN, "On a 'Phosphorus-free' Amylose from Potato Starch." CHARLES O. BECKMANN, "Studies on the Corn Amyloses. V." DOROTHEA ROBERTA BLOCK, "A New Method for the Determination of Titanium and Its Separation from Aluminum and Certain Other Elements." ANNE BOURQUIN, "Experiments on the Quantitative Determination of Vitamin G." EMMA VICTORIA CARLSSON, "Quantitative Experiments upon the Occurrence of Vitamin G in the Body, Including the Influence of the Food." WILLIAM FRANCIS FAIR, JR., "A New Treatment of Ferric Oxide Hydrosols." KURT W. HAESELER, "A Systematic Study of the Solubility of Benzoic Acid in Salt Solutions." NELLIE HALLIDAY, "Quantitative Comparative Studies of the Adsorption of Vitamins B and G from Protein-free Milk by Lloyd's Reagent." JAMES JOSEPH MCBRIDE, "A Chemical Study of Glycogen and Its Preparation." BYRON J. OAKES, "A Study of the Effect of Freezing Certain Inorganic Sols and Gels as Applied to Analytical Chemistry." PHILIPPOS E. PAPADAKIS, "The Inactivation of Sucrase and Raffinase by Heat." DONALD PRICE, "A Study of Certain Aminobenzal-Coumaranones and Structurally Related Aminochalcone Derivatives, with Special Reference to the Relation between Color and Chemical Constitution in These Compounds." EVELYN B. TILDEN, "The Response of the Monkey (*Macacus rhesus*) to Withdrawal of Vitamin A from the Diet." ROBERT P. WALTON, "Separation and Characterization of Starch Amyloses." THOMAS HILLYER WHITEHEAD, "Ion Interchanges in Aluminum Oxychloride Hydrosols." MAY LEE WHITSITT, "A Study of the Effect of Nitrous Acid on Vitamins B and G."

Cornell University

PAUL ROLLAND AUSTIN, "The Effect of Ortho-substituents on Some Reactions of Benzyl Magnesium Chloride." RAYMOND HERBERT FLECKENSTEIN, "Zinc Diethyl: Its Purification, Properties, and Manipulation. The Action of Zinc Diethyl on the Chloroforms of Carbon, Silicon, and Germanium." WILLIAM HENRY GAUGER, "Pressure-Temperature-Concentration Relations in Certain Binary Systems Containing Ammonia." LEHMAN EDWARD HOAG, "Quantitative Separation of Germanium from Silicon." EVERETT CLARK HUGHES, "The Optical Properties of Furan and Its Derivatives." ROBERT EDWIN HULSE, "The Preparation and Properties of Germanium Monoxide and Monosulfide." WALTER JOHN JEBENS, "Studies in the Plasticity of Paints." WAYNE EDWARD KUHN, "Inhibitors in the Action of Acid on Steel." ROY OLIVER MCDUFFIE, "A Study of the Binary System Silver–Germanium." CHARLES BLACKMER RUTENBER, "The Interaction between Solutions of Arsenious Oxide and the Hydroxides of Certain Metals." NORMAN ALEXANDER SKOW, "Extraction of Ger-

manium and Gallium from Germanite. Preparation and Properties of Germanium Monohydride." GENEVIEVE SPENCER, "The Formation of Pectin Jellies by Sugar." WILLIAM DWIGHT WARREN, "Equilibrium in Binary Systems with Ammonia as the Volatile Component." WARD BENJAMIN WHITE, "The Simultaneous Determination of Sucrose and Lactose in Dairy Products by Copper Reduction."

Duke University

SANFORD SWINDELL JENKINS, "The Catalytic Hydrogenation of Alpha-diketones." JOHN HENRY SAYLOR, "A Study of the Solubility of Certain Organic Substances in Aqueous Solutions."

Fordham University

FREDERICK WEBER, "A Further Investigation of the Reduction of Nitrobenzene with Dextrose in Alkaline Solution." LEO K. YANOWSKI, "Contribution to the Chemistry of Dibenzalacetone."

Harvard University

CARL RUPERT ADDINALL, "Cyclic Nitrones." NEWELL MEADE BIGELOW, "A Contribution to the Study of Free Radicals." GILES MALLALIEU BOLLINGER, "The Measurement of the Conductance of Electrolytes." ARTHUR RANDALL DAVIS, "Isoxazoline Oxides." EDWARD KENNETH HAVILAND, "I. The Quantitative Oxidation of Ammonia. II. The Synthesis of Silver Sulfocyanate. III. The Conversion of Silver Sulfocyanate into Silver Chloride." EDWIN NEWTON OHL, "Heats of Adsorption on Dehydrated Crystalline Substances."

Illinois, University of

CHESTER WALLACE BENNETT, "Attempts to Prepare Optically Active Aliphatic and Alicyclic Diazo Compounds." DONALD DRAKE COFFMAN, "I. The Reaction of Alkali Metal Alkyls with Quaternary Phosphonium Salts. II. The Synthesis of Trinondecinylcarbinol." MARTIN ELI CUPERY, "I. The Synthesis of Five Amino Acids. II. A Study of the Stereoisomerism of the Diphenyl Series (the Synthesis of Tetra-ortho-methoxydiphenyl Derivatives)." MARTIN EDWIN PAUL FRIEDRICH, "The Valence of Arsenic in Arsonium Compounds." HORACE BEAVEN GILLESPIE, "A Study of Hexasubstituted Ethanes." ESTHER MERYL GRIFFITH, "I. A Study of Hexaphenylethinylethane. II. The Structure of the Addition Compounds of Mercuric Salts and Olefines." STEWARD CLARK HUSSEY, "The Structure of Azoxy Compounds." EDWARD PETER KING, "Partial Oxidation in the Liquid Phase." OSCAR EDWARD KURT, "The Magnetic Properties of Monatomic Oxygen." HILL HARRY MACKEY, "Specific Heat of Gases at High Pressures." ROBERT WILLIAM MAXWELL, "The Preparation and Optical Activity of Certain Alkyl-aryl Compounds Similar to Optically Active Diphenyl Compounds." WENDELL WILLIAM MOYER, "Stereoisomerism of Diphenyl Compounds." WILLIAM ABNER NICHOLS, JR., "I. The Chemical Properties of Atomic Oxygen. II. An Attempt to Measure Nuclear Moments." LUCY WESTON PICKETT, "I. The Effect of X-rays on Chemical Reactions. II. An X-ray Study of the Structure of Organic Compounds." SWANIE SIGUARD ROSSANDER, "Hexa-substituted Ethanes." JOHN ALVAN SELLERS, "The Catalytic Oxidation of Oxalic Acid by Nitric Acid." EVERETT JESSE SHAW, "A Study of the Magnetic Properties of the Diatomic Sulfur Molecule." HORACE AVERY STEARNS, "Stereoisomerism of Diphenyl Compounds. Synthesis and Resolution of 2,4,6,2′,4′-Pentanitro-3-carboxydiphenyl." SHIRLEY MONROE TROXEL, "The Heats of Dissociation of Hydrogen, Oxygen, and Nitrogen." ERNEST GARDINER WALTERS, "The Vapor Pressure and the Vapor Density of Sodium." MORTIMER ALEXANDER YOUKER, "The Action of Promoters and Suppressors on the Oxidation of Hydrocarbon Fuels."

Indiana University

TROY COOK DANIELS, "Concerning the Physical Properties of Solutions of Certain Phenyl Substituted Acids in Relation to Their Bactericidal Power." EUGENE DODD SCUDDER, "Synthesis of Telluroketones." ROBERT LAVERE SHELLEY, "Expansion as the Controlling Factor in Positive Paste Compositions for Lead Storage Batteries."

Iowa, University of

JOHN BENNETT ENTRIKIN, "Effect of Substituents in the Rearrangement of Hydrazones to Pyrazolines." MILDRED M. HICKS, "Apparatus and Methods Used in the Separation and Identification of Some of the Chemical Constituents from Petroleum." EDWARD LLEWELLYN HILL, "Influence of Constitution on the Rearrangement of Hydrazones to Pyrazolines." GLENN RUSSELL MILLER, "On the Behavior of Mixed Halogenated Phenols toward Nitrating Agents." MAURICE BUELL PALMER, "Effect of a Third Substance on the Critical Solution Temperature of a Binary System." JOHN ALLEN RIDDLICK, "The Oxidation-Reduction Potentials." JOHN MARK SCOTT, "A Study of the Electrometric Titration of *d*-Glucose, Using Fehling's Solution." WILLIAM FLETCHER TALBOT, "Effect of Substituents on the Condensation of Benzaldehyde." HENRY JOSEPH WING, "A Study of the Catalytic Decomposition of Esters by Nickel."

Iowa State College

ROBERT ENOS FOTHERGILL, "Studies on the Capture of Free Organic Radicals. B. New Reactions of Oxalic Acid and Some of Its Derivatives." WALTER BERNARD KING, "The Reaction of Liquid Hydrogen Sulfide and Hydrogen Persulfide on Organic Compounds." OMAR EDWIN LOWMAN, "Effect of Salts on Alkali Disinfection." JACK D. ROBINSON, "Organo Lead Compounds." EMERY M. ROLLER, "The Effects of Organic Stimulants on Plants." JOHN B. SHUMAKER, "A Study of Caramel Color."

Johns Hopkins University

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Agglutinability, Lysis and pH of *Escherichia coli* and a Comparison of the Results Obtained with the Northrop Kunitz Cell and the Falk Capillary Cell."

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Petroleum." RAYMOND C. JOHNSON, "The Chemistry of Humus Material in Relation to Coal Formation."

Yale University

JOHN RANDOLPH HUFFMAN, "The Catalytic Decomposition of Methanol." HENRY LOUIS KELLNER, "Certain Metal Coloring Processes." MELVIN CARL MOLSTAD, "The Synthesis of Methanol by Zinc and Chromium Oxide Catalysts." EDUARD FELTBERG VON WETTBERG, JR., "Equilibrium Conditions in the Synthesis and Decomposition of Methanol."

METALLURGY

Massachusetts Institute of Technology

JOHN LEIGHTON BRAY, "Lead Coating of Sheet Steel."

Notre Dame, University of

FRANK JOSEPH MOOTZ, "Further Studies of the Action of Ferro-Alloys When Mixed with Carburizing Materials." ERNEST JOHN WILHELM, "A Metallographic Study of the Structure of Small Amounts of Copper and Mercury upon the Corrosion of Lead by Sulfuric Acid."

Heptane, Rare Resin Product, Measures Gasoline Knock. From healing wounds to measuring the knock of different gasolines seems a far cry, yet heptane, a resin product secured only from two species of pine, seems destined to serve these two widely differing purposes, C. L. Hill of the United States Forest Service, has reported.

The two trees from which heptane can be derived are just as far apart on the commercial scale. One, the Jeffrey pine, is a valuable timber species, sometimes known to the mountain people as the apple pine because of the odor of apple or pineapple that is usually emitted by its bark. This tree is found in the higher mountains throughout the greater part of California. The second tree furnishing heptane is the Digger pine, which previously has been considered a species of little value, used primarily for fuel. It occurs throughout the foothills and lower levels of both the Sierra Nevada and Coast Range of California.

While the development of heptane from an industrial standpoint is new, the curative value of the resin from these two trees, when applied to cuts and wounds, was long-ago discovered, and during the Civil War agents of the Union Armies went to far-off California to secure it. Of recent years, however, its medicinal use has dwindled, and it has been more or less classed with the herbs of our grandmothers' time.

According to Mr. Hill, it was about 20 years after the Civil War that chemists at the University of California discovered that the liquid obtained by distilling the resin of the Jeffrey and Digger pines was a hydrocarbon called normal heptane. This heptane, also commonly found in petroleum, is quite different from the terpenes which form turpentine and which were supposed to be produced by distilling the resin of any pine tree, so the announcement of its discovery caused quite a furor in the chemical world. It was many years before the findings of the California chemists were generally accepted among the chemical profession.

Even then, however, the production of heptane from pine trees had no definite commercial value. It has only recently been discovered that heptane, in connection with octane, the hydrocarbon next to it in the same chemical series, can be used for the laboratory measurement of the knock of different gasolines, and so determine the dosage of tetra-ethyl-lead that is necessary to neutralize that knock. Experiments are now in progress to perfect this method of measuring gasoline knock.—*Science Service*

Chemical Digest

INDUSTRIAL REVOLUTIONS HAVE MOLDED MODERN CIVILIZATION

Industrial revolutionists, those scientists and technologists whose genius and ideas have changed the course of our modern industrial era. are the individuals who remake and rule our civilization, Watson Davis, managing editor of *Science Service*, declared recently in a radio talk given over the Columbia nationwide network under the auspices of *Science Service*.

"We have among us today a few men whose ideas and genius, mixed often with a dash of luck, have influenced our civilization profoundly," Mr. Davis said. "Often their names are virtually unknown to the public and the man in the street benefits from their labors without knowing whom to thank if he should feel so inclined. "With apologies to Mr. James W. Gerard who recently picked a list of 'rulers of America' which was conspicuous for its lack of government officials, let me assert that while the chairmen of boards of great corporations may rule our financial and even our political destinies, they do not mold our civilization. It is not easy to pick the industrial revolutionists living among us today, but there are some who have seen their genius and hard work have a major effect on industry.

"I nominate as today's industrial revolutionists:

Thomas A. Edison, who invented the incandescent electric light, who would be perpetually famous if that were his sole gift to mankind, but who pioneered in motion pictures and a multitude of other fields.

Orville Wright, joint inventor of the airplane, who was the first to fly in a heavier-than-air aircraft, an achievement that made possible the development of the air transportation of today.

Mme. Marie Curie, because with her husband she isolated radium, the radioactive element which has found commercial use as well as utilization in the treatment of cancer and other diseases.

Guglielmo Marconi, inventor of wireless telegraphy.

Dr. Lee De Forest, whose invention of the three-element electron tube laid the foundation of the great radio industry of today and who has been a pioneer in the development of talking motion pictures.

George Eastman, because he invented photographic film which made amateur photography easy and motion pictures possible.

Dr. Elihu Thomson, electrical engineer, whose researches on alternating current laid the foundation for the extensive transmission and use of electricity today and who is the father of electric welding, the silent builder of steel skyscrapers.

Dr. Fritz Haber and **Carl Bosch,** who, working for the great I. G. chemical combine of Germany, developed the production of synthetic nitrogen from the air by the direct

synthetic ammonia process on such a scale and so economically that agriculture and industry is made independent of the natural nitrates of Chile.

Dr. Leo H. Baekeland, chemist, who invented bakelite, the synthetic plastic made from formaldehyde and carbolic acid, and who invented velox photographic paper.

Georges Claude, French inventor and engineer, who devised the method of liquefying oxygen and other gases, invented the neon electric lamp and is now working on a method of obtaining power from the temperature differences in seawater.

Frederick E. Ives, inventor of the halftone process of illustration reproduction that is used thousands of times every day throughout the world in the printing of magazines, newspapers, and books.

The Group of Bell Telephone Research Laboratories Engineers, Headed by Dr. Herbert E. Ives, son of the halftone inventor, who brought talking motion pictures by two processes to such commercial perfection that the motion picture industry went sound nearly overnight, who also perfected a process in television over wire and radio, and who has constantly improved the telephone.

Dr. W. D. Coolidge, General Electric physicist, who invented the X-ray tube in common use which bears his name, and who invented the tungsten filament electric light.

Dr. Frederick Bergius, German chemist, who invented the hydrogenation of coal process with which oil can be made from coal and which is now being used in the refining of petroleum, and who is now developing a process for making edible carbohydrates from waste wood and other cellulose products.

Dr. Michael I. Pupin, who rose from immigrant to inventor, because of his invention of loading coils for telephone lines which makes possible conversations across continents.

Dr. F. G. Cottrell, who invented the electrical precipitation of fine dust and other particles which is used to such advantage by smelters, cement plants, and other industries that otherwise would pour out wastes that would pollute the air that we breathe.

Dr. William M. Burton, whose process of cracking petroleum has made possible the production of enough gasoline to run the automobiles of the world.

Sir Charles Parsons, the British engineer who invented the steam turbine.

Sir Robert A. Hadfield, English metallurgist, who pioneered in the production of manganese and silicon alloy steels.

H. Brearley and **Dr. W. H. Hatfield,** English metallurgists, who pioneered in the production of stainless or rustless steels which now have wide commercial use.

Dr. Irving Langmuir, General Electric chemist, who invented the gas-filled electric lamp and atomic hydrogen welding.

The group of American chemists, including **Prof. H. P. Cady** of the University of Kansas, **Dr. R. B. Moore,** and **Dr. F. G. Cottrell,** then of the U. S. Bureau of Mines, and their associates, who during the World War extracted from natural gas the sun element, helium, hitherto known only as a rare inert elemental gas, and supplied it in such quantities that it now floats large airships.

C. Francis Jenkins, inventor, who pioneered in motion pictures and radiovision.

Chemists of the du Pont Companies, who developed a new kind of paint, pyroxylin lacquer, and made it possible to paint automobiles with a cellulose compound.

Chemists of the I. G. Farbenindustrie A. G., Germany's dye trust, who produced new dyes, drugs, and other synthetic organic chemicals.

Dr. Robert M. Yerkes and his psychological associates who during the war devised the army mental tests which demonstrated to industry the utility of such tests.

Clifford W. Beers, "the mind that found itself," who, because of his experiences in an insane asylum, founded the mental hygiene movement which is rescuing thousands from mental illness.

Dr. S. M. Babcock, University of Wisconsin chemist, whose test for butter-fat content of milk put the dairy industry on a firm scientific basis.

Dr. L. O. Howard, veteran government entomologist, who long led America's war on the insect and who aroused the nation to the necessity of fighting insect invaders which menace health, crops, and livestock.

Prof. George H. Shull, botanist, who showed how to breed corn of higher yield that has meant millions of dollars to American farmers.

Dr. John Mohler, chief of the U. S. Department of Agriculture's Bureau of Animal Industry, whose vigorous fight against foot-and-mouth disease of cattle has subdued that scourge and saved the livestock industry untold loss.

Dr. Marion Dorset, Department of Agriculture biochemist, who developed methods of immunizing pigs against cholera and thus saved heavy losses in the industry of hog raising.

Dr. Theobald Smith, dean of American bacteriologists, whose work on Texas fever removed the menace of that disease of cattle, but, more important, proved that insects can carry disease.

Dr. Casimir Funk, who invented the term vitamin and called the attention of students of nutrition to early work on beri-beri. This ushered in intensive research upon vitamins with resulting changes in food habits.

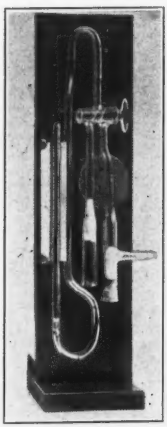
"To this list there should also be added many pioneers in medicine whose researches have conquered many diseases. And there cannot be included in this list, although perhaps they should be, the names of thousands of individuals who have aided in the birth of new ideas or perfected them so that they could do industry's work. Great and important names in science, such as Einstein, Michelson, Millikan, Morgan, Rutherford, and a host of others are not in this list because their work, for the most part, has not yet been translated into industrial effects. That they are affecting the world's thought stream is undoubted; that even the most abstruse scientific discoveries will have industrial results in the future cannot be doubted."

Chemist Finds Arsenic and Germanium in Meteorites. Arsenic, favorite of poisoners, and germanium, a rare element that has been used in the treatment of anemia, are both present in some meteorites that fall to the earth from the skies. Dr. Jacob Papish and Zaida M. Hanford, Cornell University chemists, have just completed a series of analyses of six meteorites. Traces of germanium were found in all of them, while small amounts of both germanium and arsenic were actually extracted from two. The meteorites were studied by placing portions of them in an electric arc, and studying the light from the arc with a spectroscope. Certain lines, known to be due to germanium, were clearly apparent in all the specimens studied. By a complicated chemical treatment, which started with distillation of hydrochloric acid in which the meteorites had been dissolved, perceptible amounts of arsenic and germanium were extracted from one that fell in Mexico and another that fell in Canada. Up to the present, the only place outside the earth in which germanium has been located is in the outer layer of the sun, where it has also been found with the aid of the spectroscope. Claims have been made in the past of the identification of arsenic in meteorites, but there has been some controversy about it.— *Science Service*

ABSTRACTS

APPARATUS, LABORATORY PRACTICE, AND DEMONSTRATIONS

An Improved Manometer for the Organic Laboratory. *Syn. Org. Chem.*, **4,** No. 1 (Oct., 1930).—Adding the second tube and two-way stopcock permits releasing the mercury column with outside air. The advantage is that no distillate vapor can enter the tube and contaminate the mercury.



The U-bend is rounded out to give strength to the tube; the capillary constriction in the left column prevents breaking the tube from opening the vacuum line suddenly. H. H. K.

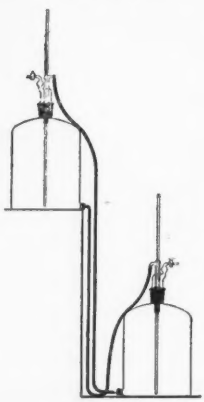
New Photo Flash Lamp. ANON. *News Ed., Ind. Eng. Chem.*, **8,** 12 (Sept. 10, 1930). —"A fireless, smokeless, odorless, and noiseless photographic flash lamp has been developed by the incandescent lamp department of the General Electric Co., Cleveland, Ohio. The flash is confined entirely within a bulb, with resulting advantages that are expected to revolutionize flashlight photography. Requiring only one-hundredth of a second to act, and being without hazard, it will make possible the taking of flashlight photographs in places heretofore practically impossible to 'shoot,' such as in trains, airships, and theaters, under water, and by insurance companies requiring night photographs under all weather conditions.

"The lamp consists of a clear bulb of standard design, with the flashlight filament coated with a special preparation, and with a quantity of very thin aluminum foil in crumpled sheet form within the bulb. The bulb is oxygen-filled.

News Ed., Ind. Eng. Chem.

NEW PHOTOGRAPHIC FLASH-LAMP BULB BEFORE USE. CLOSE-UP VIEW

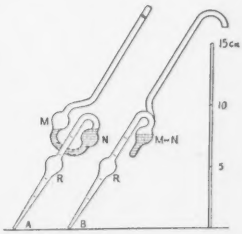
"When the circuit is closed the filament is lighted and this in turn lights the foil. The lamp operates on any 115-volt house supply, or with dry, storage, or flashlight batteries. A new lamp is needed for each flash. The lamp is most efficient when used with suitable reflector equipment." G. W. S.



An Aspirator for the Production of Constant Gas Pressure. F. FRIEDRICHS. *Chem.-Ztg.*, **54,** 667 (Aug. 27, 1930).—An aspirator producing a constant gas pressure is necessary for many types of chemical work. The apparatus shown in the drawing does away with the time-consuming filling of the aspirator. The working of the apparatus is simple and self-evident from the figure. The two bottles are of similar shape and contain the same standardized glass stopper. They are therefore interchangeable. The aspirator is patented and manufactured by Greiner and Friedrichs, Stutzerback, Thüringen, Germany. L. S.

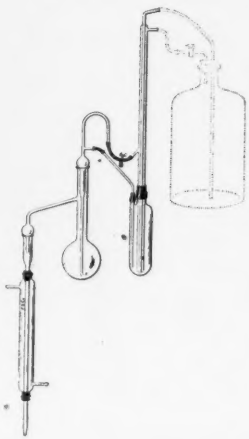
A New Bath Wax. *Laboratory*, **3,** 61 (1930).—A new wax is now available to take the place of paraffin in high-temperature baths. The wax has a melting point of about 60°C.; does not smoke appreciably at 270°C.; flash point at 325°C. H. H. K.

A Rapid Positive Control Method of Handling Small Quantities of Liquids. E. L. HARRINGTON. *Science*, **71**, 201–2 (Aug. 22, 1930).—The pipet shown in the figure substitutes a mercury plunger or piston for the usual rubber bulb or rubber tube connected with the mouth. By inclining the pipet at an angle such as indicated and rotating it until the mercury has filled bulb *N* the air on the *N* side is crowded out at the tip. If now the tube, still at the same angle, is inserted into the liquid supply and rotated about its own axis until the mercury runs from bulb *N* into bulb *M* the liquid will be drawn up into the pipet to a height dependent both on the angle of inclination and the amount of rotation, each of these conditions being subject to definite control individually. To expel any quantity of the liquid one has but to rotate the pipet in the reverse direction, the mercury flowing back into *N* bulb and crowding out the liquid to an extent positively controlled by either the inclination or the rotation, or both.



G. H. W.

A Method for Making Conductivity Water. *Laboratory*, **3**, 60–1 (1930).—"The Riegembald still steps up the purity of distilled water.



"A slight suction applied to the top of the flask inlet tube brings the water into the flask in which a constant level is thereafter automatically maintained."

H. H. K.

The Electrometric Titration of Phosphoric Acid and Superphosphate Solutions Using the Antimony Electrode as Indicator. J. C. VOGEL. *Chem. & Ind.*, **49**, 297T–300T (July 11, 1930).—The method does not require complicated apparatus, it is rapid and accurate. Typical results are shown in graphical form. E. R. W.

Removal of Water from Organic Compounds. *Syn. Org. Chem.*, **4**, No. 1 (Oct., 1930).—A brief discussion of various ways of dehydrating organic compounds. H. H. K.

Hydrogen-Ion Indicator Chart. *Laboratory*, **3**, 56–7 (1930).—Seventy indicators, covering the full pH range, are charted, showing their useful range and color change. H. H. K.

The Safe Handling of Poisonous Chemicals. J. P. ROGERS. *Chem. Age*, **23**, 137 (Aug. 16, 1930); 159–60 (Aug. 23, 1930).—"A cloth moistened with soda solution is often used by workers as a protection against small concentration of acid fumes."

A concentration of chlorine of 0.0000015% breathed for an hour or so each day will often prevent or cure colds or influenza, but a concentration of 0.04% has been found fatal.

Hydrogen sulfide will produce toxic symptoms in concentrations as low as 0.005%, while exposure to a concentration of 0.02% for several days may cause death. At higher concentrations it resembles carbon monoxide in rapidity of action.

Carbon monoxide is especially dangerous because it is odorless. The victim of carbon monoxide poisoning should be carried to the open air, warmth should be applied, and if necessary artificial respiration (Schafer's method) applied, and oxygen, if available, should be administered.

Nitrous acid fumes, methyl alcohol, and chlorinated hydrocarbons should not be inhaled.

Hydrogen cyanide and nicotine are powerful poisons.

Benzene poisoning caused by breathing benzene vapors may lead to chronic anemia.

Aromatic amino and nitro compounds are dangerous blood poisons which may be absorbed through the skin.

A list of poisonous chemicals with their antidotes is given, as well as suggestions for a first-aid kit and directions for its use. E. R. W.

First-Aid Kit. See **The Safe Handling of Poisonous Chemicals** above.

Scientific Instrument Makers of the 18th Century. See this title on page 2996.

TEACHING OBJECTIVES, METHODS, AND SUGGESTIONS

A Contract Plan of Teaching General Science. D. F. OSBOURN. *Calif. Quart. Sec. Educ.*, **11**, 256–60 (April, 1930).—The author describes an increasingly popular method of teaching science—the contract plan. General science is divided up into topical units of work, called "contracts," requiring from ten days to two weeks for completion. The method of presenting the contract differs from that frequently used. Students may receive a grade of "fair," "good" or "excellent"—depending on the quality and amount of work completed. The students prefer this method; the teacher does less talking and more teaching; pupils receive valuable training in the use of the library and in using reference materials; less laboratory equipment is needed; individual differences are more adequately taken care of; students work independently; discipline problems seem almost to disappear; little loss of time or energy; relieves monotony; work more easily made up; students learn how to study. C. M. P.

An Experiment in Teaching. H. H. WHETZEL. *Sci. Mo.*, **146**, 151–62 (Aug., 1930).—The same article published under this title in *J. Higher Educ.*, **1**, 125–35 (Mar., 1930) and reported in J. CHEM. EDUC., **7**, 1414 (June, 1930). See also editorial, *ibid.*, **7**, 1228–9 (June, 1930). G. W. S.

Teaching the Slow-Minded in High Schools. See this title on page 2998.

Is the History of Pharmacy a Worth While Study? G. D. BEAL. *J. Am. Pharm. Assoc.*, **19**, 1–2 (July, 1930).—Address of the chairman, Section on Historical Pharmacy, American Pharmaceutical Association, 78th annual meeting, Baltimore, Md., May 5–9, 1930. The close relationship that has always existed between chemistry and pharmacy is pointed out. The author concludes that following the history of pharmacy, or of any other profession or art, accomplishes the following things: "(1) It serves to impress the student with the extent to which observation, experience, and the unconscious grasping at conveniences which almost automatically present themselves will eventually direct energies along labor-saving lines to economical manufacturing operations. (2) It brings to the mind of the student more forcefully than in any other way the interdependencies that exist among the natural sciences, causing a realization of what may be learned each from the other and what may be gained by the encouragement of mutual respect and intercourse. (3) By tracing the history of medicinal agents and pharmaceutical operations from their beginnings, it aids in formulating for the student the theories of these operations and behaviors. (4) Finally, by relating the studies and labors of the masters, it develops in the mind of the apprentice the thought of pharmacy as an honorable profession, one ranking above mere trades." C. E. M.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

Is It Possible to Meet the Needs of Both the College and the High-School Admission Requirements? W. M. PROCTOR. *Calif. Quart. Sec. Educ.*, **2**, 326–8 (June, 1930).—There is a growing tendency among American colleges to make their admission requirements more liberal and to do away with the entrance examination of the College Entrance Examination Board type. The plan proposed to substitute in the place of a specific pattern of subjects taken in high schools the following evidences of fitness on the part of the candidate to do work on the college level: first, a scholarship rating based on the marks earned in all the subjects taken in the 10th, 11th, and 12th grades; second, an intelligence or aptitude test; third, a composite character trait rating scale; and fourth, evidence of seriousness of purposes, leadership qualities, vocational choice presented in application blanks, letters, and recommendations, supplemented by personal interviews where possible. C. M. P.

KEEPING UP WITH CHEMISTRY

Commerce of Chemistry. J. N. TAYLOR. *Science*, **71**, 153–7 (Aug. 15, 1930).—The author gives a discussion of the general progress of chemistry in industry.

Economic trends or commodity tendencies may be caused by several factors among which may be noted (1) the influence of other industries upon chemical evolution and (2) the intrusion of synthetics into fields of use already occupied by natural products. To these factors of outstanding interest to the chemist may be added (3) those of availability of natural resources and (4) waste and co-product utilization.

Further, the creation of a new industrial South has resulted from a recognition of its vast potential resources and the availability of cheaper power and new methods and lines of transportation. The South has been a new stimulus to the advancement of industrial chemistry. G. H. W.

Progress of Chemistry in Industry. See **Commerce of Chemistry** on page 2988.

Chemistry and the Petroleum Industry. A. E. DUNSTAN. *Chem. & Ind.*, **49**, 310T–20T (July 18, 1930).—An interesting account of the types of work and opportunities for the chemist in this industry, including work in the oil fields, refinery, in development, and in research. Problems still to be solved in cracking and in refining are discussed. E. R. W.

Some Recent Food Investigations. S. DIXON. *Chem. & Ind.*, **49**, 645–9 (Aug. 1, 1930); 663–8 (Aug. 8, 1930).—A discussion of the composition of food and food analysis from the viewpoint of the physiological chemist, with special attention being paid to the occurrence, properties, and identification of the different vitamins. E. R. W.

Activated Alumina. *News Ed., Ind. Eng. Chem.*, **8**, 28 (Sept. 20, 1930).—"Activated alumina, specially prepared, partially dehydrated aluminum trihydrate in the form of hard porous masses, has been developed recently by the Aluminum Research Laboratories. Prior to the development of this new form, alumina was obtainable commercially only as a powder manufactured by the Bayer process, or as a slag produced by electrothermal processes. The absorptive properties of partially dehydrated alumina in powder form have been known for many years, but because of its physical condition, few, if any, commercial applications were possible. The preparation of the material in the form of hard masses permits of grading into sizes ranging from a powder to pieces approximating 1.5 inches in diameter. Its stability, high purity, inertness to chemical action, large surface area or porosity per unit volume, together with the affinity of alumina for vapors and gases, combine to form the basis of commercial merit for the product.

"The complete removal of moisture is of particular interest in the liquefaction of gases and where the presence of a small quantity of moisture in gases causes corrosion, explosive hazard, or limits the reactability of the gas. Other typical drying applications are air-conditioning, the drying of blast, the dehydration of ammonia, hydrogen, chlorine, hydrochloric acid, carbon dioxide, oxygen, etc.

"The removal of chlorine from hydrogen and hydrogen sulfide from carbon dioxide illustrates its property of removing one gas from another. Furthermore, its applications as a dehydrating catalyst in the organic chemical field and as a catalyst carrier are extremely promising because of the inertness, purity, and structure of the material."

G. W. S.

High-Pressure High-Temperature Technology. N. W. KRASE. *Chem. & Met. Eng.*, **37**, 530–3 (Sept., 1930).—High-pressure high-temperature processes have become an established business rather than an experimental project. The leading high-pressure high-temperature product is synthetic ammonia. The United States is at the present time entirely independent in the matter of nitrates from this source. The price has been reduced from 30 cents per pound to 15 cents per pound when sold in cylinder lots, and when sold in tank car lots it may be obtained as cheap as 6 cents per pound. Synthetic methanol has increased from nothing in 1920 to nearly five million gallons in 1929, and the price has been reduced from 90 to 40 cents per gallon. High-pressure high-temperature process for production of methanol has made competition keen for the wood distillation method. Hydrogenation of petroleum under high temperature and pressure, and in the presence of a catalyst, makes it possible for a 100% conversion of petroleum into high-grade gasoline. The future of this field of production is very promising. It is expected that in the near future all the higher alcohols will be produced by this method. R. L. H.

Synthesizing Methanol from By-Product Gases. EDIT. *Chem. & Met. Eng.*, **37**, 548–9 (Sept., 1930).—The development of synthetic methanol in the United States with a discussion of the process. Illustrated. R. L. H.

Toxic Effect of Methanol under Study. ANON. *Chem. & Met. Eng.*, **37**, 595 (Sept., 1930).—The Bureau of Mines at its Pittsburgh station is investigating the toxic effect of anti-freeze mixtures containing methanol. There is a belief that there will be danger of poisoning from inhaling the fumes and absorbing methanol through the skin. There seems to be no evidence that natural wood-alcohol workers have ever suffered from breathing the fumes or from absorbing wood alcohol. R. L. H.

The Government's New Helium Plant at Amarillo, Texas. C. W. SEIBEL. *Chem. & Met. Eng.*, **37**, 550–2 (Sept., 1930).—Control was obtained of gas rights from the virgin wells at Amarillo, Texas, which comprised about fifty thousand acres. The gas from these wells contain about 2% helium, and the pressure is sufficient that compression of the gas is unnecessary for separation of the helium. The gas is quite high in carbon dioxide and it is necessary to wash the gas with caustic soda before separating the helium to prevent the carbon dioxide from solidifying in the pipes. In the first process of puri-

fication only about 80% helium is obtained, but a second purification gives a purity of approximately 98%; a purity which has never before been reached. The helium after separation is shipped at 1800 to 2000 pounds' pressure in tanks mounted on cars or in small cylinders. R. L. H.

But an Apprentice in Nature's Workshop. H. LEVINSTEIN. *Chem. & Ind.*, **49**, 303T–10T (July 18, 1930); see also *Chem. Age*, **23**, 45–6 (July 19, 1930).—The president's address delivered to the Society of Chemical Industry. Attention is called to the industries based on coal and coal-tar products and to the fact that carbon dioxide of the air is the sole source of carbon contained in the coal. We will sometime need to know how to convert this carbon into food and raw material. We have already succeeded in reducing carbon dioxide to methane. Is this not a landmark in human history? E. R. W.

Cenospheres and the Structure of Coke. F. S. SINNATT. *Chem. & Ind.*, **49**, 335T–8T (Aug. 8, 1930).—The structure of cenospheres (hollow spheres formed by allowing particles of caking coal to enter an inert medium maintained at a definite temperature) and of coke appear to be related, and evidence indicates that coke is a foam. The surface of coke may contain as many as 10,000 particles to the sq. mm. E. R. W.

Poisonous Chemicals and Their Antidotes. See **The Safe Handling of Poisonous Chemicals** on page 2987.

The Copper Resources of British Africa. ANON. *Chem. & Ind.*, **49**, 721–4 (Aug. 29, 1930).—Recent discoveries of extensive deposits of high-grade copper ore in Northern Rhodesia have proved to be the biggest mining sensation of recent times. There is no doubt but that in the near future this region will become an important factor in the copper production of the world. Much of the ore so far proved contains from 3% to 5% copper. E. R. W.

The Production and Uses of Stearin and Olein. H. BRAUN. *Chem. Age*, **23**, 118–9 (Aug. 9, 1930).—Modern methods of obtaining these materials and some of their chief uses are outlined. E. R. W.

Cadmium versus Zinc Plating as Rust Preventive. W. S. PATTERSON. *Mo. Met. Sect., Chem. Age*, **23**, 7–8 (Aug. 2, 1930).—Both cadmium and zinc form excellent protective coatings for indoor use. Zinc appears to be much better than cadmium for out-door exposure. E. R. W.

World Productions of Sodium Sulfate. ANON. *Chem. Age*, **23**, 161–2 (Aug. 23, 1930).—Extract from a review of the world's resources of sodium sulfate compiled by H. O. Moraw. Crude sodium sulfate (salt cake) is one of the basic raw materials for the following industries; heavy chemical, rayon and textile, glass and ceramics, and kraft paper. E. R. W.

pH and Silicates. ANON. *Silicate P's & Q's*, Sept., **1930**, No. 10.—One of the distinguishing characteristics of modern manufacturing operations is control. Economical production requires the most favorable conditions available, one of which many industries find to be pH. Silicates offer to these industries a method of controlling the pH value, with the additional advantage of maintaining such values because of their buffer action. By proper choice of silicates they may be used at any pH value over a wide range. H. T. B.

Froth Smothers Biggest Oil Blaze. ANON. *Pop. Sci.*, **117**, 20 (Aug., 1930).—A new weapon for fire fighters enabled workers to control the big oil blaze at the Gulf Refining Co.'s Bayonne, N. J., refinery. The substance is a foam of carbon dioxide which is produced when solutions of sodium bicarbonate and alum meet. An extract of licorice makes the foam tenacious. Most refineries are equipped with permanent pipes leading to each storage tank, and also portable outfits. H. T. B.

Basic Intermediates for Dyestuffs; No. 36. The Amino Naphthol Sulfonic Acids. *Dyestuffs Mo. Suppl., Chem. Age*, **23**, 5–6 (July 12, 1930). E. R. W.

Basic Intermediates for Dyestuffs; No. 37. Some Oxy Derivatives of Anthracene and Anthraquinone. *Dyestuffs Mo. Suppl., Chem. Age*, **23**, 11–2 (Aug. 9, 1930). E. R. W.

Timber as a Material of Plant Construction. E. A. RUDGE. *Chem. & Ind.*, **49**, 697–704 (Aug. 22, 1930).—A detailed discussion of the structure of wood of different kinds, methods of preparing it for use, and preserving it from wet rot, dry rot, and the ravages of insects and borers. Different industries which have found wood indispensable as a material of plant construction are mentioned. America seems to be behind other nations in re-afforestation of cut-over lands. E. R. W.

Structure of Wood. See **Timber as a Material of Plant Construction** above.

The International Chemical Fertilizer Industry. C. C. CONCANNON. *Chem. Age*, **23**, 78–9 (July 26, 1930).—Although the fertilizer industry was founded primarily

to serve as an outlet for waste products of other industries it has grown in importance until now it is the giant of the chemical industries. A review of the international situation with respect to inorganic nitrogen, Chilean nitrate, phosphoric acid, and potash.
E. R. W.

The Healing Activity of Organic Compounds Containing the Sulfhydryl Group. *Syn. Org. Chem.*, **3**, No. 5 (June, 1930).—It was noted that parts of roots in which growth by cell division normally occurred most rapidly gave the strongest test with nitroprusside showing a concentration of the sulfhydryl grouping.

This led to a series of experiments on roots and animals which showed the power of the —SH group in aiding the production of new tissue. Thiocresol was used with marked effect in treating patients at the Lankenau Hospital in Philadelphia.
H. H. K.

Absorption Spectrography and Some of Its Applications to Chemistry. F. TWYMAN. *Chem. & Ind.*, **49**, 535–7 (June 27, 1930); *ibid.*, **49**, 556–9 (July 4, 1930); *ibid.*, 49, 578–81 (July 11, 1930).—Whenever a chemist draws a deduction from an observed color he is utilizing a crude absorption spectroscopy. When a quartz spectrograph is substituted for the eye we have a very powerful method of discriminating between different substances, estimating their strength or purity, and observing the rates of chemical reactions. The underlying theory, the apparatus, and the technic involved are described in detail. The article is well illustrated.
E. R. W.

Quantitative Microanalysis. R. T. K. CORNWELL. *Hexagon*, **20**, 311–6 (Mar., 1930).—The microanalytical methods which were developed by Pregl have proved of far-reaching importance to the chemist. Dr. Kamm of the Parke, Davis & Company Research Laboratories, has isolated the active principles of the pituitary glands. This material is worth $5000 per gram and it would have cost $1000 to have made an analysis by the ordinary combustion method. By microanalysis 0.002 g., which was worth $10, was used. It is suggested that students be instructed in the methods of microanalysis, for to them belongs the future.
R. L. H.

The Mercuration of Phthaleins in Neutral Solutions with Bichloride of Mercury. F. R. GREENBAUM. *Am. J. Pharm.*, **102**, 535–44 (Sept., 1930).—This is a piece of research growing out of the interest aroused in the preparation of mercurochrome, a hydroxymercuridibromfluorescein. The introduction of mercury into phthaleins was patented by the Fahlberg List & Co. and August Klages. In 1920 Edwin C. White of The Johns Hopkins Hospital published his investigations on the introduction of mercury into phthaleins which resulted in the synthesis of mercurochrome.
G. O.

The Daturas. F. B. KILMER. *Am. J. Pharm.*, **102**, 526–34 (Sept., 1930).—These drug plants, some of them of old-world origin, others belonging to the new world, have been used from remote antiquity as intoxicants and medicines. Entwined in the history of every race we find a story of the use of some variety of datura. The Asiatic "metel nut" is the species that figures most prominently in history. Wherever found, the daturas first appear conspicuously in symbolism and in religious ceremonies. Amid the ruins of the ancient people who once lived in the southwestern United States there are found the seed and seedpods of the daturas. The priests of the Temple of the Sun, now in the Republic of Colombia, were observed as preparing a narcotic drink called "tonga" from a red-flowered datura (*D. Sanguinea*). The Mexican *Torna loco* or "maddening weed" is an aquatic datura. A remarkable feature in connection with these plants is the independent discovery in remote parts of the world of their narcotic effects. In the Peruvian Andes tree daturas are found fruiting in altitudes up to 12,000 ft. where there is frost every night. These plants owe their virtues to certain mydriatic alkaloids, principally to atropine, hyosycamine, and scopolamine to which may be added the more recently discovered solandrine. Our Jimson Weed assumed prominence during the World War at which time the solanaceous drugs, especially belladonna, became very scarce. It was then found that Jimson Weed was a valuable source of atropine.
G. O.

Rockets to the Moon. W. H. WENSTROM. *Rev. Reviews*, **488**, 96, 99 (Sept., 1930).—The possibilities of travel through the outer reaches of empty space have always been alluring. This article of popular interest describes how a madman's dream of not many years ago—the idea of firing a rocket into outer space—is now backed by science and business.
G. H. W.

Why Your Fireworks Flash and Go Boom. A. P. ARMAGNAG. *Pop. Sci.*, **117**, 38 (July, 1930).—A small air space is left in the fire cracker so that gases from the burning powder may build up pressure which on reaching a certain value bursts the container with a loud report. The makers have found that aluminum or magnesium filings added to the old-fashioned powders produces a healthy kick. Various types of powders have

been perfected; some burn slowly and may be used as fuses, others burn extremely rapidly. Chemical compounds are added to produce color. H. T. B.

Plant Pill. ANON. *Pop. Sci.*, **117,** 26 (July, 1930).—Dr. W. F. Gericke, of the University of California, is working on a "plant pill" which is a plant food concentrate containing nitrogen, phosphorus, magnesia, iron, potassium, and sulfur in amounts balanced to fit the soil on which it is to be used. Large increases in yield and quality of product have been reported by truck gardeners and wheat farmers who have used it. Certain lumber companies are using it to cut down the time a seedling stays in the nursery. H. T. B.

Water. EDIT. *Gen. Elec. Rev.*, **33,** 483 (Sept., 1930).—It is odd that man is often oblivious to that which is obvious. How little we know of water, and how widespread and important are the results of its work! In rivers and oceans, waterfalls and tides there is much to interest the engineer and social economist. The babbling brooks and mountain peaks, the rocky crags of which may be sedimentary deposits carried down to an ocean by land erosion ages before, offer starting points for the poet's flights of fancy. The little molecules or molecular aggregates of water interest the scientist because of their properties. H. T. B.

Gas War Defense and Protection from Gases of Peace. ANON. *Sci. News Letter*, **18,** 106 (Aug. 16, 1930).—While Poland provides first aid for surprise gas attacks in the event of war the United States Bureau of Mines is perfecting a carbon monoxide detector which, by the aid of palladium chloride, shows the presence of not only that gas but of a number of other poisonous gases. The hazard of asphyxiation by natural gas may be lessened, thanks to the work of the same bureau, if a trifling amount of ethyl mercaptan is introduced before it is distributed to the consumers. The mercaptan is closely related to grain alcohol in structure but is radically different from it in properties. Its smell is its most conspicuous property, seeming to be the opposite of all that is objectionable in odors. B. C. H.

Dehydration of Organic Compounds. See **Removal of Water from Organic Compounds** on page 2987.

Carbon Dioxide Foam Used for Fire Fighting. See **Froth Smothers Biggest Oil Blaze** on page 2990.

High Pressures and Temperatures in Industry. See the entire issue of *Chem. & Met. Eng.* for Sept., 1930.

Industries Based on Coal and Coal-Tar Products. See **But an Apprentice in Nature's Workshop** on page 2990.

Alkaloids. See **The Daturas** on page 2991.

Atropine. See **The Daturas** on page 2991.

Mercurochrome. See **The Mercuration of Phthaleins in Neutral Solutions with Bichloride of Mercury** on page 2991.

Thiocresol. See **The Healing Activity of Organic Compounds Containing the Sulfhydryl Group** on page 2991.

Vitamins. See **Some Recent Food Investigations** on page 2989.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES

Some Recent Advances in Theoretical Organic Chemistry. R. C. FUSON. *Chem. Reviews*, **7,** 347-68 (Sept., 1930).—The author summarizes certain trends apparent in the development of valence theory at the present time as follows:

"1. The so-called classical considerations, *viz.*, the number of bonds, their spatial arrangement, and the problem of bond distortion, still engage the attention of the majority of investigators. These problems continue to yield highly significant results, illustrative examples of which have been mentioned.

"2. Certain rather surprising developments, notably the explanation of the isomerism of diphenyl compounds and the theory of strainless rings, seem to require the return to a more rigid type of model for the tetrahedral carbon atom.

"3. The electron theory of valence has consolidated the various fields of chemistry by an explanation of the differences in the bonds characteristic of these fields.

"4. Finally, it might be pointed out that the great importance of the problem of reaction mechanism has gained more general recognition. Nothing is more eloquent of this than the vast amount of work which has been done in an attempt to apply the new valence theory to the problem. Moreover, nothing shows more clearly than these attempts the real inadequacy of the theory in its present form. Reaction mechanism certainly calls for a dynamic theory of valence, and in this respect the new theory is open to essentially the same criticism as was the old—it is a static theory. It might be pre-

dicted, and it is certainly to be hoped, that the next great step ahead in the field of valence will be in this direction." Bibliography included. C. E. M.

The Polymerization Reactions of Ethylene. H. M. STANLEY. *Chem. & Ind.*, **49**, 349T–54T (Aug. 22, 1930).—A discussion of the polymerization of unsaturated hydrocarbons in the presence of metallic chlorides and its relationship with the Friedel-Crafts reaction. E. R. W.

The Effect of the Rate of Cooling on Steel. J. M. ROBERTSON. *Mo. Met. Sect., Chem. Age*, **23**, 1–2 (July 5, 1930).—A critical examination of the accepted theories on the effect of heat treatment on steel. E. R. W.

Some Recent Food Investigations. See this title on page 2989.

Fifty Years in the Chemical Industry. L. BROTHERTON. *Chem. Age*, **23**, 67–9 (July 26, 1930). See also *Chem. & Ind.*, **49**, 330T–33T (Aug. 1, 1930).—The fifth Messel Memorial lecture. Reminiscences of fifty years' experience in the chemical industry. E. R. W.

HISTORICAL AND BIOGRAPHICAL

Stephen Moulton Babcock, Inventor of Milk Test. See **Capper Award** in **Local Activities** on page 3002.

Theodor Curtius. C. DUISBERG. *Z. angew. Chem.*, **43**, 723–5 (Aug. 16, 1930).—The article is a reprint of a speech given by the author on the occasion of the Theodor Curtius memorial celebration of the Heidelberger Chemischen Gesellschaft on May 3, 1930.

The author became acquainted with Curtius at Munich in 1882 when the latter was working as an assistant to Adolf Baeyer after having received his doctor's degree in Leipzig. Curtius distinguished himself very quickly by his excellent research work on hippuric acid and similarly constituted synthetic amino acids. He is the discoverer of the diazo fatty acids and of hydrazoic acid. In 1889 he was called to Kiel as professor and director of the Institute, in 1897 to Bonn as successor to August Kekulé, and in 1898 to Heidelberg as successor to Victor Meyer. There he remained until March, 1926.

During the forty years of his academic career, Curtius has lectured to thousands of students. More than one hundred and fifty of these students, Germans and foreigners, received their doctor's degree under his guidance.

He was an excellent teacher and experimenter and was well liked by his students and colleagues. L. S.

Herbert H. Dow. See this title in **Local Activities** on page 3003.

Michael Faraday, Electro-Chemist. *Laboratory*, **3**, 51–3 (1930).—A short biography with a copy from Faraday's notebook of his first experiment on "the production of electricity from magnetism." H. H. K.

Per K. Frolich Awarded Grasselli Medal. See **Grasselli Medal** in **Local Activities** on page 3003.

August Kekulé. A. BERNTHSEN. *Z. angew. Chem.*, **43**, 719–22 (Aug. 16, 1930).—The article is a reprint of a speech given by the author on the occasion of the Theodor Curtius memorial celebration of the Heidelberger Chemischen Gesellschaft on May 3, 1930.

Friedrich August Kekulé von Stradowitz started his brilliant academic career at the University of Heidelberg in 1856 and remained there until 1858. He had to instal his own laboratory and lecture room while the state provided the chairs for the students. The laboratory, which was very primitive, consisted of one room without any hood and a kitchen. The lecture room and laboratory were located in a small private house, one floor above his modest apartment. Among his first students were Adolf Baeyer and Reinhard Hoffmann. Soon came Landolt, Carius, Pebal, Roscoe, Lothar Meyer, Beilstein, and others.

Those were the days of great struggles in the field of theoretical chemistry. In Germany there was still prevalent the old dualistic manner of writing chemical formulas as taught by Berzelius and based on an electrochemical foundation. The symbols of the elements represented just equivalent weights; formulas of the type shown below were used on the basis of H = 1, O = 8, C = 6, etc.:

HO	HO,SO_3	HO,KO	C_4H_5O,HO alcohol	$C_4H_3O_3,HO$ acetic acid

In France there had risen the substitution theory which opposed the electrochemical manner of writing by its recognition of the similarity between acetic acid and chlorinated acetic acid. Gerhardt had developed the simpler formulas which were based on the atomic weights of the elements as H = 1, O = 16, C = 12, etc. Thus:

H_2O H_2SO_4 KHO C_2H_6O $C_2H_4O_2$.

These formulas were traced back to simple types which at first were only of mechanical importance, as:

$$\begin{matrix} H \\ H \end{matrix} \qquad \begin{matrix} H \\ Cl \end{matrix} \qquad \begin{matrix} H \\ O \\ H \end{matrix} \qquad \begin{matrix} H \\ HN; \text{ also } \\ H \end{matrix} \qquad \begin{matrix} K \\ O \\ H \end{matrix} \qquad \begin{matrix} C_2H_5 \\ O \\ H \end{matrix} \qquad \begin{matrix} C_2H_3O \\ O. \\ H \end{matrix}$$

Williamson, the chief exponent of the new atomic weight ideas in England, who was working on mixed ethers wrote their formulas in a similar way, as *e. g.*: $\begin{matrix} C_2H_5 \\ O. \\ CH_3 \end{matrix}$ In 1851, Gerhardt was working on simple and mixed acid anhydride and he wrote formulas such as $\begin{matrix} C_2H_3O \\ O. \\ C_2H_3O \end{matrix}$

Kekulé became deeply interested in this theoretical problem and had many occasions to discuss with Gerhardt a number of disputable points as well as the classification of organic compounds. In the meantime Williamson had recognized that the existence of dibasic acid presupposes the assumption of double types and polybasic radicals as CO in the case of carbonic acid and SO_2 in the case of sulfuric acid. He wrote their formulas thus: $\begin{matrix} CO \\ O_2 \\ H_2 \end{matrix}$ and $\begin{matrix} SO_2 \\ O_2. \\ H_2 \end{matrix}$

In 1854, Kekulé published an article on thioacetic acid in which he showed that one atom of sulfur was equivalent to two atoms of chlorine. Kekulé felt that this idea was the germ of his later theory of the atomicity of the elements.

The type theory had thus developed in several directions. Besides the simple type there was the double type, as *e. g.*:

$HgCl_2$ $(SO_2)''Cl_2$ $\begin{matrix} H_2 \\ O_2 \\ H_2 \end{matrix}$ $\left.\begin{matrix} (SO_2)'' \\ H_2 \end{matrix}\right\} O_2$ $\left.\begin{matrix} (C_2O_2)'' \\ H_2 \end{matrix}\right\} O_2$ Glycol $\left.\begin{matrix} C_2H_4 \\ H_2 \end{matrix}\right\} O_2$ Würtz, 1856

There was the triple type:

$\left.\begin{matrix} H_3 \\ H_3 \end{matrix}\right\} O_3$ $\left.\begin{matrix} (C_3H_3)''' \\ H_3 \end{matrix}\right\} O_3$ $\left.\begin{matrix} CH''' \\ Cl_3 \end{matrix}\right\}$ $\left.\begin{matrix} (PO)''' \\ H_3 \end{matrix}\right\} O_3$

and also the mixed types indicated by Williamson and developed by Kekulé:

$\left.\begin{matrix} H \\ (SO_2)'' \end{matrix}\right\} \begin{matrix} O \\ Cl \end{matrix}$ Chlorhydrin sulfuric acid

$\left.\begin{matrix} H \\ H \\ (C_2O_2)'' \\ H \end{matrix}\right\} \begin{matrix} N \\ \\ \\ O \end{matrix}$ Oxaminic acid

During the discussion of the multiple and mixed types there rose the question of the replacement value or valence of the radicals such as CH_3', CO'', CH, etc., and also of the elements themselves. Kekulé then assigned the valence of four to carbon and recognized a fourth type, namely $\begin{matrix} H \\ H \\ H \\ H \end{matrix}$C. From this type he derived $\begin{matrix} H \\ H \\ H \\ Cl \end{matrix}$C equal to $(CH_3)Cl$, $\begin{matrix} H \\ H \\ H \\ NH_2 \end{matrix}$C equal to $\begin{matrix} (CH_3)' \\ H \\ H \end{matrix}$N, etc. In 1857 Kekulé published his famous theoretical paper on "The So-Called Paired Compounds and the Theory of Polyatomic Radicals." Half a year later there followed an article on "The Constitution and Metamorphoses of Chemical Compounds and the Chemical Nature of Carbon." He recognized that there are mono-, di-, tri-, and tetravalent elements and suggested the following combination types: I + I; II + 2I; II + II; III + 3I; III + II + I; IV + II + 2I; etc.

During his stay at the University of Heidelberg, Kekulé began to write his famous textbook. He was also one of the founders of the *Kritische Zeitschrift für Chemie.*

In 1858, after having taught for five semesters at Heidelberg, he was called to the University of Ghent. From there his fame spread to the whole world. In 1865, Würtz presented to the Societé Chimique in Paris a paper of Kekulé which dealt with the theory of the benzene nucleus. In 1867 he was called to Bonn and 1875 to Munich as successor to Liebig. He died in 1896 at the age of 67 years. L. S.

J. A. Le Bel. W. J. PAPE. *Nature*, **126**, 374 (Sept. 6, 1930).—The death of Joseph Achille Le Bel, which occurred in Paris on August 6th, removes one whose name has become historical in the field of organic chemistry. Le Bel, who was born January 21, 1847, was a nephew of Boussingault, the agricultural chemist. He was also after his student days an assistant to Balard, the discoverer of bromine, and to Würtz. The study in France of optically active compounds had been carried on by Biot and Pasteur. As a means of explaining Pasteur's conclusions the theory of the asymmetrical carbon atom was put forward independently and practically simultaneously by van't Hoff and Le Bel, and after a short time was adopted universally by chemists.

Le Bel arrived at the theory in a somewhat different manner from van't Hoff. "He discussed the mode in which the four univalent radicals attached to a quadrivalent carbon should arrange themselves as a pure question of equilibrium and hence arrived at the tetrahedral environment of the central carbon atom with the same consequences, as regards asymmetry, as those of van't Hoff.

"Le Bel was the first to separate an optically active component from the synthetic mixture of the two mirror image components of a compound containing an asymmetric carbon atom; he did this in most cases by taking advantage of the selective destructive action of lower organisms on the levo- and dextro-isomerides. He was also the first to show that when the asymmetric carbon atom of an optically active substance of the type, $CWXYZ$, becomes symmetric by conversion into the allied compound, CX_2YZ, the optical activity disappears.

"Le Bel did not publish a great deal of experimental work, probably because he held no academic position. He was an individualist with a great originality of thought, though his unconventionality made him somewhat difficult of access.

"Le Bel was president of the French Chemical Society in 1892; he was a Commander of the Legion of Honor and a member of the Paris Academy of Sciences. He was elected an honorary fellow of the Chemical Society in 1908 and a foreign member of the Royal Society in 1911; in 1893 both he and van't Hoff became Davy medalists of the Royal Society." F. B. D.

Julius Lothar Meyer. *Nature*, **126**, 250 (Aug. 16, 1930).—On August 19th occurred the centenary of the birth of the German chemist, Julius Lothar Meyer. A student of Bunsen and Kirchoff at Heidelberg, he became *Privatdozent* at Breslau in 1859. In 1876 he succeeded Fittig in the chair of chemistry at Tübingen, where he remained until his death in 1895.

"The life of Lothar Meyer was written by his pupil Seubert, while the memorial lecture to the Chemical Society was delivered by Prof. P. P. Bedson in 1896. With great intellectual gifts, Lothar Meyer possessed characteristics which gained for him the esteem and appreciation of his contemporaries. Though his scientific publications embraced a great variety of subjects, his name is best known for the share he had with Newlands in England and Mendeléeff in Russia in the periodic classification of the elements. Speaking of the Periodic Law, Thorpe said: 'The first chemist of note to grasp the significance of Mendeléeff's generalization was Lothar Meyer, who, dealing at the outset with one of the characteristic properties of the elements—*viz.*, their specific or atomic volumes—greatly developed the principle of periodicity, representing it graphically in a most striking and suggestive manner, leading up to a classification almost identical with that of Mendeléeff.' It was for this work that Lothar Meyer was awarded the Davy medal in 1882. Lecturing three years later, Meyer himself spoke of Mendeléeff's contribution as forming 'the coping stone of the building which in the course of years has been erected on the foundation of Döbereiner's Triads, as a work which did not, like Pallas Athene, spring ready armed from the head of a Jove, but has been gradually completed by the slow, painstaking, and often apparently vain endeavors of a whole series of workers.'" F. B. D.

Pregl. See **Quantitative Microanalysis** on page 2991.

Dr. J. J. Van Laar. *Chem. Weekblad*, **27**, 418–27 (July 12, 1930).—This number of the journal is largely devoted to an appreciation of Professor Van Laar. One article by F. E. C. SCHEPPER is on Dr. Van Laar's seventieth year, another on Van Laar as a scientist by J. E. VERSCHAFFELT.

Van Laar was born on the 11th of July, 1860, at The Hague. His earlier education was at the Naval Institute and he made a number of voyages as a lieutenant in the

navy before his graduate work at Amsterdam with van't Hoff and Van der Waals. He was teacher in various schools in Holland and then, on account of his health, spent a long time in Switzerland. Despite this the appended bibliography is amazingly long. F. B. D.

J. H. Vogel. M. GREVEMEYER. *Z. angew. Chem.*, **43**, 743 (Aug. 23, 1930).—Dr. J. H. Vogel died on March 24, 1930. He was one of the founders and directors of the section for water chemistry.

He was born in 1862 in Hannover as the son of a physician, studied natural sciences and mathematics at Halle and Freiburg, and afterward devoted himself entirely to the study of chemistry and physics in Göttingen. In 1886 he began his studies at the University of Göttingen under Lothar Meyer. Soon he published his first work on fertilizers and animal food. After his graduation he worked for a short time as an assistant in a brewery. Then the government of Portugal called him to Coimbra where he installed an agricultural laboratory. There he remained for three years. During this time he published a large number of analytical and agricultural studies. In 1891 he was called back to Berlin where he accepted the position of an assistant at the College of Agriculture. A year later he became scientific director of the fertilizer division of the German Agricultural Society. In 1895 he published an outstanding book on "The Utilization of City Sewage." In 1897 he founded his own laboratory where he was continually studying problems concerning waste liquor and the rational purification of industrial waste water. During the next twenty years he studied particularly the waste water of the potash industry. His book on this subject appeared in 1913. Very frequently he was consulted as a chemical expert in many lawsuits dealing with industrial waste liquors.

Besides the two books already mentioned he also published the following books: "Dictonary on Acetylene" (1904); "Acetylene" (1923); "Calcium Carbide and Acetylene as Raw Materials for the Manufacture of Chemical Products" (1924); "Remarks Concerning the Acetylene Regulations" (1928). He was an editor of the *Fachzeitschrift für Autogene Metallbearbeitung* and of the journal *Acetylen in Wissenschaft und Industrie*. L. S.

Scientific Instrument Makers of the 18th Century. R. S. WHIPPLE. *Science*, **71**, 208–13 (Aug. 29, 1930); [*cf.* J. CHEM. EDUC., **7**, 2193 (Sept., 1930)].—Here is given a brief description of the accomplishments of a few men whose work has done an immense amount to popularize science and to raise the standard of scientific instrument craftmanship. G. H. W.

Carthaginian Lenses. *Nature*, **126**, 415 (Sept. 13, 1930).—This is from a communication by Mr. H. L. Taylor in the *British Journal of Physiological Optics* on the "Origin and Development of Lenses in Ancient Times." This ascribes the development of the lens to the Cretans of 1800 B. C. Plano-convex lenses have been found at Cnossus. The Phoenicians appeared to have carried such lenses to the mainland. "At Carthage five glass lenses have been unearthed at the ancient Necropolis, two of them of power 5.5 diopters in the sarcophagus of a prominent individual, who it is presumed suffered from presbyopia and wished to protect himself against this disability in his next existence." F. B. D.

Hide to Leather via the Chemical Route. ANON. *Dyestuffs*, **31**, 134–8 (Sept., 1930).—A brief history of tanning. (Reprinted from *Chem. Markets.*) A. E. C.

EDUCATIONAL MEASUREMENTS AND DATA

Some Sex Differences in the Achievements of High-School Seniors in North Carolina. M. R. TRABUE. *High-Sch. J.*, **13**, 212–5 (May, 1930).—A uniform test was given to 14,100 North Carolina seniors in February, 1930. Of the total number of seniors, 37.9% were boys and 62.1% were girls, with median ages, respectively of 17.9 and 17.5 years. The test consisted of eleven sections and tested, among other things, the student's comprehension in reading biological science materials and his knowledge of general science. The boys made a median score of 72.2 and the girls made a median score of 68.8. This superiority was true at every age tested. Younger pupils made higher scores than older pupils. One explanation of the sex differences offered by the author is that North Carolina high schools are effective selective agencies and that the boys who do not find the curriculum suitable for their needs, leave school and go to work, while less opportunity is offered the girl for similarly leaving school. Thus a larger per cent of non-academic boys are eliminated than non-academic girls. C. M. P.

A Report on College Freshmen for the First Semester of 1928–29. C. R. MAXWELL. *North Cent. Assoc. Quart.*, **4**, 484–600 (Mar., 1930).—This is a report of the Committee on Special Studies of the Commission on Secondary Schools of the North

Central Association. The report is based on a study of 2080 schools, 671 higher institutions and 41,079 students. The subject failures of each student entering college are listed according to the secondary school from which the student graduated. (Secondary schools are grouped by states.) The tables show that 25.7 per cent of freshmen students failed in one or more hours for which they were registered, the average percentage of hours failed being 9.4 per cent. Schools having enrolment less than 100 have the smallest percentage of failures and schools of over 3000 have the greatest percentage of failures. The percentage of failures from private high schools was greater than for public high schools. Data on Central Association and Southern Association follow:

	North Central	Southern Association
Percentage of graduates going to college	37.7	43.8
Percentage of semester hours failed	9.4	14.5
English	7.9	13.5
French	9.8	15.7
History	8.0	13.1
Latin	6.7	10.8
Mathematics	16.0	23.8
Science	12.2	19.2
Spanish	14.6	19.4
Other subjects	6.2	8.7

State universities and state colleges failed 33.3 per cent of the students while teacher training institutions failed 17.2 per cent; junior colleges 21.3 per cent and private colleges and universities 25.9 per cent. The respective percentage of semester hours failed were 12.7 per cent, 5.5 per cent; 20.9 per cent and 24.2 per cent. Findings in this study verified the findings of a study made in 1924–25. C. M. P.

Enrolment in North Central Association Secondary Schools. REPORT OF THE COMMISSION ON SECONDARY SCHOOLS. *North Cent. Assoc. Quart.*, **5**, 103–19 (June, 1930).—The June issue is devoted to reports of various committees made at the March, 1930, meeting. Among the reports are those on: Unit Courses and Curricula; Secondary Schools; Higher Institutions; Committee on Athletics and Professional Training of College Teachers. A list of standards of the North Central Association is included. The Quarterly lists not only the members North Central Association (both secondary and higher institutions) but includes institutions of higher education accredited by regional associations other than the North Central Association. A report on enrolment by subjects in North Central Association secondary schools is included. The present enrolment in the 2226 schools reporting is 1,006,537.

	Enrolment	*% of Total Enrolment*		*No. Schools Offering*
		1930	1925	
General Science	125,331	12.4%	11.5	1143
Physical Geography	20,459	2.0	5.3	420
Geology	2,633	.2		47
Biology	118,356	11.8	9.4	1542
Botany	19,267	1.9		269
Zoölogy	13,489	1.3		180
Physiology	28,375	2.8		576
Physics	76,643	7.6	8.5	1818
Chemistry	89,013	8.8	8.8	1568
Miscellaneous	1,900	.2		21
Total	225,893	49.0	43.5	7584

C. M. P.

Sugar Will Give You Endurance. J. W. BOOTH. *Pop. Sci.*, **117**, 35 (Aug., 1930).—Tests recently conducted on a group of Colgate University students indicate that carbohydrates reduce fatigue, and increase coördination of mind and muscle. The students were divided into two groups. One group was given a sugar solution the first three days of the test, and saccharin solution the last three days. The other group was given saccharin exclusively. The solutions were administered 40 minutes before a period of exercise. Tests were conducted before and after the exercise period. H. T. B.

Four Types of Tests. D. R. WATSON AND C. C. CRAWFORD. *High-Sch. Teacher*, 6, 282–3 (Sept., 1930).—The tests referred to are: essay, completion, best-answer, and true-false. Ten experiments were conducted to determine the relative ranking of them

from two angles. The subject matter used in the tests was physics. Controls used, procedures employed, and treatment of results are discussed. The two outcomes used as means of ranking them were the test's time demand for its construction, administration and scoring and its precision as a measure of successful study. The ranking of them in terms of the first outcome is: essay, best-answer, completion, and true-false, with the last least time-consuming. As a measure of successful study the completion test holds first place with essay, best-answer, and true-false following in the order given. B. C. H.

Experimentation as a Technic of Educational Research. M. D. ENGELHART. *Phi Delta Kappan*, **13**, 58–60 (Aug., 1930).—Controlled experimentation is used in educational procedures as in physical sciences as a means of determining the relative effectiveness of methods and practices.

The effectiveness of this technic in education is conditioned by five factors: (1) selecting a true representative sample of school children to work with; (2) getting equivalent groups selected from this sample; (3) making certain of the control of non-experimental factors; (4) making a correct measurement of gains in achievement; (5) properly handling and interpreting the data.

Judging from experiments reported the worst offender among the above factors are (3) and (4). Some non-experimental factors whose control has embarrassed the experimenter are: teacher preferences, preparation time used by pupils, and personality traits of teachers. Measurement of gains are possible by use of reliable tests. The validity of these tests is not always certain, however. In fact the present much-debated relative efficiency of laboratory compared with demonstration as a method of science teaching is largely a criticism of the validity of the test used in the studies reported. B. C. H.

Selecting Textbooks on Health. J. M. ANDRESS. *Hygeia*, **8**, 662–3 (July, 1930).—Any program of health education cannot do its best without the use of a textbook as one of its tools.

Some characteristics of a best textbook are listed as: (1) Is it scientifically accurate? (2) Does it promote wholesome attitudes? (3) Is it practical? (4) Is it interesting? (5) May it be studied without eye strain? (6) Is it teachable? Each characteristic is discussed and clarified by concrete examples from the books themselves. B. C. H.

THE PHILOSOPHY OF EDUCATION

Aristotle and Aristotelianism in Education. R. W. HOLMES. *Progr. Educ.*, **7**, 185–90 (May, 1930).—The author points out the chief characteristics of Aristotle and indicates his influence upon education. Aristotle's reputation is unique in the superlatives and absolutes which it contains. He mastered human knowledge in a supreme sense that can be challenged by the memory of no other man of wisdom. Aristotle was a natural scientist. His father was a physician and his characteristic method of learning was induction; his point of view was objective; his primary source of knowledge was the outer world. He was a psychologist and conceived of education as habit formation. He believed in education for leisure time and emphasized physical education. He was conservative and practical and the first great logician. He is credited with writing between 400 and 1000 volumes, only fragments of which remain. Aristotle was a scientist and he may well be called the father of all science, both natural and speculative. His contribution to education is inestimably larger than that of any other man who ever lived. C. M. P.

Baccalaureate Degrees. E. N. MOSHER. *North Cent. Assoc. Quart.*, **4**, 473–83 (Mar., 1930).—The author traces the origin of the different baccalaureate degrees conferred by various universities and colleges in the different countries. The granting of degrees originated during the twelfth century in Italy and France. Of the different university degrees, the Master's came first in point of time. Present practices in granting degrees as well as the significance of any degree vary considerably in the different countries. In Scotland the first degree is practically the only degree conferred by the universities. A detailed comparison of the various baccalaureate degrees offered by colleges and universities of the North Central Association of Colleges and Secondary Schools is included. The author found that 149 colleges offered the A.B. degree; 114 offer the B.S. degree; 37 offer an educational degree; 84 offer a degree in music. C. M. P.

Teaching the Slow-Minded in High Schools. W. H. DOOLEY. *School*, **41**, 885–6 (Aug. 14, 1930).—History shows that high schools have been prone to look to colleges for courses and methods of instruction. The result has been emphasis upon abstract knowledge and then the use of the logical unit system of organization.

For the slow-minded pupils, who are more numerous than are the abstract-minded,

such methods have little appeal. These have until recently been educated almost wholly in the grades or by apprenticeship.

The master craftsman under the apprentice system taught and arranged his trade skills and information in a very different manner from the logical order of the teacher of pure arts and sciences. That order was "first practice, then thinking about the practice." In other words his was a "psychological order and the spiral arrangement and not the logical order and unit arrangement."

In order to make the use of this method more certain and concrete the author offers four changes to be made in the present academic procedure in high schools: (1) courses of study should be developed from trade or occupation analyses; (2) the problems or projects of the different courses should be made to arise in a vital, natural way and should, when once under way, be projected into the related English, chemistry, physics, arts, biology, mathematics, and economics essential to their successful solution; (3) there should be such machinery set up as will appraise the interests of elementary school graduates and by means of tests and interviews place them in courses and with groups where their individual abilities will count for most toward their vocational preparation; (4) provision should be made for many part-time students who may divide their year between school and employment and thus aid in maintaining themselves by their earnings while continuing school. B. C. H.

Antecedents of the Federal Acts Concerning Education. E. H. REISNER. *Educ. Record*, **11**, 196–207 (July, 1930).—In this article the author discusses the important factors that have entered into the evolution of the federal government's participation in education. He points out that education is not even mentioned in the Constitution. On the other hand the Constitutional Convention did not discuss and pass upon it negatively. Education had not yet risen to be a sufficiently important matter of public policy. The real beginning of federal participation in education began with the introduction of a bill by Representative Justin Morrell in 1857 (passed in 1862) to create agricultural and mechanical colleges on an endowment of the public domain. However, the real period of development of Federal participation in education began about 1890. Since that time the Smith-Lever Act, Smith-Hughes Act, Purnell Act, and Capper-Ketcham Act have been passed and more and more government departments are concerned with education until now the federal government is spending over forty million dollars annually on education. At present there is a tendency to increase federal participation in education. C. M. P.

Federal Relations to Education. C. R. MANN. *Educ. Record*, **11**, 60–100 (April, 1930).—This is a relatively complete summary pointing out the significant factors connected with federal relations to the various educational interests of the country. The article summarizes several hundred digests of articles showing federal relations to education. The digests discussed in order of increasing frequency are: Negro Education; Department of Superintendence of the N. E. A.; U. S. Department of Education; Federal Board for Vocational Education; The American Vocational Association and the Association of State Directors of Vocational Education; The Supreme Council 33 degree Ancient and Accepted Scottish Rite of Freemasonry, Southern Jurisdiction; Indian Education; Association of Land Grant Colleges and Universities; National Catholic Educational Association; American Federation of Labor; National Association of State Universities; and American Home Economics Association. C. M. P.

THE PHILOSOPHY OF SCIENCE

Can Science Control Life? L. HYDE. *Atlantic Mo.*, **146**, 242–52 (Aug., 1930).—The social sciences are compared with the physical sciences in their methods of attack and the reliability of their conclusions. The physical sciences are on the way to providing us with the means of modifying and controlling our terrestrial environment; sociology may one day enable us to master the incalculably more formidable problem of modifying and controlling ourselves. In the physical sciences, it happens that the measurable quantities give an understanding of the fundamental nature of the physical universe while in the social sciences it is the "imponderables" which are of most significance. It is for this reason that H. concludes that those who are placing their hopes for the future of the race in our anthropologists and sociologists would be well advised to watch their behavior with peculiar care. G. W. S.

CONTEMPORARY NEWS AND COMMENTS IN CHEMISTRY AND EDUCATION

Thirteenth Exposition of Chemical Industries. See this title in **Local Activities** on page 3005.

Research Foundation to Exploit All Salable Scientific Developments of Staff of University of Wisconsin. See **University of Wisconsin, Madison, Wis.**, in **Local Activities** on page 3015.

Conference of Fellowship Donors at The Johns Hopkins University. See **The Johns Hopkins University, Baltimore, Md.**, in **Local Activities** on page 3008.

National Institute of Public Health. See this title in **Local Activities** on page 3004.

Museum of the Peaceful Arts. See this title in **Local Activities** on page 3004.

Capper Award. See this title in **Local Activities** on page 3002.

John J. Carty Medal and Award for the Advancement of Science. See this title in **Local Activities** on page 3002.

Grasselli Medal. See this title in **Local Activities** on page 3003.

One Hundred Sixty-Fifth Anniversary of the University of Pennsylvania Medical School. See **University of Pennsylvania, Philadelphia, Pa.**, in **Local Activities** on page 3014.

Inter-American Institute of Intellectual Coöperation. See this title in **Local Activities** on page 3004.

Antecedents of the Federal Acts Concerning Education. See this title on page 2999.

Federal Relations to Education. See this title on page 2999.

The Library of Mellon Institute of Industrial Research. L. HEATON. *News Ed., Ind. Eng. Chem.*, **8**, 7–9 (Oct. 10, 1930).—Description of library and contents, with illustrations. C. E. M.

Chemical Research at Teddington, England. See **A State Experiment in Chemical Research** on page 3001.

Chemistry in the New "Encyclopaedia Brittanica." ANON. *Chem. Age*, **23**, 3–4 (July 5, 1930).—Because of the rapid growth in all branches of science it was necessary to condense the space devoted to chemistry to about five-sixths of that allotted to it in the earlier edition. Fifty-five pages are devoted to the main article, "Chemistry." Several scholarly articles by well-known authorities are included in this and related topics. E. R. W.

The American Association for the Advancement of Science: The Fourteenth Annual Meeting of the Pacific Division. J. M. LUCK. *Science*, **71**, 255–65 (Sept. 12, 1930). G. H. W.

Theodor Curtius Memorial Celebration of the Heidelberger Chemischen Gesellschaft. See **August Kekulè** on page 2993.

The Achema VI. *News Ed., Ind. Eng. Chem.*, **8**, 15–6 (Sept. 20, 1930).—An account of the international exhibition of chemical apparatus held at Frankfurt a/M, June 10–22, 1930, under the auspices of the Dechema—the *Deutsche Gesellschaft für chemisches Apparatewesen*. Illustrated. C. E. M.

Institute of Physical and Chemical Research, Madrid, Spain. See this title in **Local Activities** on page 3017.

FOREIGN CHEMICAL AND EDUCATIONAL CONDITIONS

Vocational Education in Porto Rico. See this title in **Local Activities** on page 3006.

The Newer Aspects of German Education. M. H. JAMES. *Progr. Educ.*, **7**, 225–30 (June, 1930).—Fundamental changes have been made in the German school system since the World War. The "new education" in Germany is new both in organization and policy. Entrance to higher education is now based upon superior ability and achievement rather than ability to pay. The new *Grundschule* is the foundation of all education in Germany. It is not a separate school but consists of the first four grades (for children six to ten years of age) of the eight-grade free elementary school which offers the minimum requirements of compulsory education. All children of whatever social or religious group, must attend the *Grundschule*. All private schools have been closed. Instruction in the *Grundschule* is less rigid and more informal. After the *Grundschule* course is completed, pupils may go directly into the upper four years of the free elementary schools (*Volkschule*) or pass by examination either into the *Mittelschule* or the *Gymnasium*. (The latter two are six-year schools.) Their choice usually depends upon their mental ability, their vocational interests, and their ability to pay. One of the important characteristics of the new education is that mental ability is the chief basis of educational opportunity. Graduates of the *Volkschule* may continue for six years in the new free *Gymnasium*, called the *Aufbauschule*. Pupils in this school are preparing to be teachers. This school is rapidly gathering together the pick of the brains of the country. Girls go to the Lyceum which provides a six-year education for girls. Since the war an

additional three-year school has been added (called the *Frauenschule*) which enables girls to go to the universities, a privilege not previously available. Entrance to the universities from the secondary school is gained by passing a rigid examination. The principle of self-activity now permeates the secondary as well as the elementary school. Universities have changed least. Now all elementary teachers must pass through the secondary school and take a special two-year course for teachers. The secondary teacher must go to the university for five years and then give an additional three years for the writing of his thesis, psychological training, and practice teaching. Thus it takes 15 years of study for elementary teacher training and 21 for the secondary teacher training. In both cases appointment is for life and at 65 the secondary teacher receives 80 per cent of his salary as a pension for life. C. M. P.

A State Experiment in Chemical Research. *Nature*, **126**, 363–4 (Sept. 6, 1930).—The subject of Professor G. T. Morgan's address to Section B (Bristol meeting of the British Association) was the Chemical Research Laboratory at Teddington, which was founded by the Department of Scientific and Industrial Research to bring together the scattered groups who were engaged in chemical researches of national importance. Following are listed the main types of investigation carried out during the past five years:

(1) Synthetic resins from formaldehyde and the cresols and xylenols.

(2) A systematic study of the chemical constituents of the tars from low-temperature carbonizations. The outstanding result is the isolation of four chemical groups of resins and the characterization of several methyl derivatives of anthracene.

(3) Studies in the use of pressure in facilitating chemical reactions and the products formed by the interaction of carbon monoxide and hydrogen. (Synthesis of alcohols, etc.).

(4) The corrosion of metals. An interesting discovery is that the patina on copper in England is not a basic copper carbonate but is mainly a basic copper sulfate.

(5) The study of the preparation of organic compounds of therapeutic interest. Analogs of Baeyer 205 or Fourneau 309, together with many organic derivatives of arsenic and antimony, have been synthesized.

(6) Studies on the base exchange (zeolite) method of water softening. It has been found that the silica content of waters is not seriously increased.

In addition much other general research has been carried out along organic lines. F. B. D.

Research in England. See **A State Experiment in Chemical Research** immediately above.

GENERAL

Science and the Span of Life. T. S. HARDING. *North Am. Rev.*, **101**, 216–22 (Aug., 1930).—Various instances of long life are given along with an interesting discussion on science as related to longevity. G. H. W.

New Flakes of Ice Speed Cooling. Science has produced flakes of ice which would be ideal for cooling beverages and home ice cream freezers, but they are being applied to large scale industrial processes of chemical engineering.

Flake ice is much more useful than block ice and even crushed ice for many chemical purposes because it melts so fast. Ten pounds of flake ice will melt twelve and a half times as fast as a 10-pound block, Crosby Field recently told the American Institute of Chemical Engineers. Thus it will cool a chemical reaction generating heat much faster than other forms of ice.

"The new ice looks very much like broken peanut brittle except for color," Mr. Field said. "A 300-pound standard cake of ice has a surface area of 20.7 square feet whereas 300 pounds of one-eighth inch thick flake ice has 1000 square feet of surface, an area nearly 50 times as great. But the effective ratio of surface area in use is far greater than that indicated by these figures because the surface of the flakes remains practically unchanged as they melt while the area of a block gets much smaller."

Flake ice is formed on a drum full of brine that rotates in water. Rollers within the drum distort its surface and peel the thin sheets off, at the same time cracking them up into small pieces.—*Science Service*

Local Activities

Purpose and Organization

The purpose of the Local Activities Section of the JOURNAL OF CHEMICAL EDUCATION is briefly but clearly stated in its title. Any items of local news from educational or scientific institutions, A. C. S. Sections, Teachers' Associations, or other organizations which are of such a nature as to make them of more than purely local interest rightfully belong to this Section.

The responsibility of reporting items for this section rests entirely with the local institutions and organizations. It is desirable to have a representative appointed to report news regularly. Suitable material sent to the editorial office before the 20th of each month will be published in the following month's journal. The Editorial Staff must necessarily reserve the right to abridge or totally reject any items submitted. If the following suggestions are followed, however, the necessity for such action will be largely obviated.

Material to Be Reported

1. Notices of local scholarships or fellowships and announcements of new or unusual courses in chemical education or special fields of chemistry.
2. Reports of dedication of new science buildings, stressing the unique features.
3. News notes concerning activities of prominent scientists and educators and of the honors and awards made to them.
4. Promotions within, or changes of personnel of, a department.
5. Notices of any special gifts to chemical organizations or departments—as fellowships, endowments, laboratory gifts, library gifts, etc.
6. Accounts of meetings, social functions, exhibitions, chemical entertainments, etc., which might be suggestive to other organizations. Where original or unusual features are included, it is desirable that they be described in some detail.

GENERAL

Capper Award. *Science Service* announces that for his invention of a milk test that has helped honest dairymen and foiled the milk-watering penchant of dishonest ones, DR. STEPHEN MOULTON BABCOCK has been given the first annual Capper Award for distinguished service to American agriculture. At the thirteenth annual banquet of the American Country Life Association in Madison, October 9th, the 87-year-old agricultural chemist received $5000 and a gold medal awarded him by a committee of prominent agriculturists. SENATOR ARTHUR CAPPER, donor of the annual award, made the presentation speech.

The award of the $5000 prize marked the first riches that have come to Dr. Babcock from his invention of the Babcock test to determine the butterfat content of milk and his many other important discoveries. Though the scientist could have reaped great wealth by patenting his invention, he preferred to make a gift of his process to the farmers who produced milk and the families who bought it.

His other inventions include a viscometer, still used to measure the viscosity of liquids and to detect adulteration of oils. He also enabled farmers to calculate mathematically the amount of cheese obtainable from their milk and perfected a method of separating casein from milk and revolutionized methods of curing cheese. Working with H. L. RUSSELL, formerly dean of agriculture at the University of Wisconsin where Dr. Babcock is professor emeritus, he discovered the reason why pasteurized milk becomes thinner and devised a method of restoration.

John J. Carty Medal and Award for the Advancement of Science. *Science Service* reports that a new honor and award that will be given to leading scientists of the future was established through the acceptance by the National Academy of Sciences of a trust fund of $25,000 presented by a group of officials of the American Telephone and Telegraph Company in honor of GENERAL JOHN J. CARTY who recently retired from active connection with the scientific research of that national telephone organization.

The John J. Carty Medal and Award for the Advancement of Science which will be supported by this fund may be "either

for specific accomplishment in some field of science or for general service in the advancement of fundamental and applied science." It is to be awarded without regard to race, nationality, or creed.

The donors of the fund explained that the award was established as a testimonial to General Carty's "noteworthy contributions to the advancement of fundamental and applied science and in appreciation of his great service for many years in developing the art of electrical communication."

Herbert H. Dow. DR. HERBERT H. Dow, president, general manager, and

founder of the Dow Chemical Co., Midland, Michigan, died unexpectedly on October 15th following an operation at the Mayo clinic, Rochester, Minn.

Dr. Dow was born in Belleville, Ontario, on February 26, 1866, of American parentage. He spent his early youth in Connecticut but was educated principally in Cleveland, where he graduated from the Case School of Applied Science in 1888, where he first became interested in the recovery of lithium and bromine. After a short experience as professor in chemistry and toxicology at the Huron Street Hospital College in Cleveland, he became interested in the manufacture of chemicals and in 1890 he organized the Midland Chemical Co. and Dow Process Co., which eventually became the Dow Chemical Co. Under his executive administration and practical management, this company has reached the status of a successful producer of more than two hundred different chemical compounds. *News Edition, Industrial and Engineering Chemistry* states: "Bromine gave him an early opportunity to beat foreign competition at its own game and is a product for which the firm is known around the world. Indigo, aniline, synthetic phenol, the salicylates, magnesium, including Dow metal, the compounds of sodium, calcium, magnesium and chlorine, and more recently para- and ortho-phenyl phenol, diphenyl, and other organic compounds are but an indication."

The most recent of many honors bestowed upon Dr. Dow was the Perkin medal presented to him on January 10th of the present year at a meeting of the Society of Chemical Industry, American Chemical Society, Société de Chimie Industrielle, and American Electrochemical Society. At the time of his death he was one of the five nominees whose names were proposed by a ballot of the entire chemical industry for the *Chemical Markets* Medal to be awarded for the most distinguished economic services to American chemical industries. [See **American Chemical Industry Selects Five Leaders,** JOURNAL OF CHEMICAL EDUCATION, **7,** 2512–3 (October, 1930).] He was also one of the nominees for president-elect of the American Chemical Society.

Grasselli Medal. The award of the Grasselli Medal for 1930 by the American Section of the Society of Chemical Industry to PER K. FROLICH, of the Standard Oil Development Company, for his work on the synthesis of high pressure has been announced in *Science.* The medal was presented at a joint meeting

of the Chemical Societies in New York at Columbia University on November 7th. PROFESSOR W. K. LEWIS spoke on the accomplishments of the medalist.

Inter-American Institute of Intellectual Coöperation. *School and Society* has announced that CARL H. MILAM, secretary of the American Library Association, has accepted membership on the National Council of Intellectual Coöperation for the United States. The council is being organized by the Inter-American Institute of Intellectual Coöperation, established last February in Havana. Its aim is to coöperate with other national councils in the "study and solution of the problems of intellectual life in the Americas."

Museums of the Peaceful Arts. *Science* states that MR. FELIX M. WARBURG, vice-president of the Museums of the Peaceful Arts, New York City, has received the golden ring of the Deutsches Museum presented by the government of Bavaria. Mr. Warburg has been actively interested in the Deutsches Museum, as also in the development of industrial museums in America.

The Museum of Science and Industry is projecting an extensive color exhibition, covering all the scientific and technical phases of color, to begin in January and to continue for two months. DR. F. C. BROWN, formerly assistant director of the U. S. Bureau of Standards, is director of the Museum; MR. I. G. PRIEST, chief of the colorimetry section of the Bureau of Standards, is chairman of the advisory committee; and DR. I. H. GODLOVE, formerly of the Munsell Color Co., is in charge of arrangements for the exhibition. A number of industrial corporations are expected to exhibit instruments and apparatus for measurement and demonstration of light and color, besides which the committee plans various instructive, educational and scientific features designed to make the color-using public better acquainted with the work of scientists in the field.

National Institute of Public Health. The Chemical Foundation of New York recently presented to the government the sum of $100,000 for the endowment of a fellowship in the newly established National Institute of Public Health for the purpose of research in the chemical industry. The presentation was made to MR. ANDREW W. MELLON, Secretary of the Treasury, by Mr. WM. W. BUFFUM, General Manager and Treasurer of The Chemical Foundation.

New England Association of Chemistry Teachers. The 125th meeting of this organization was held on Saturday, October 18th, at Bulkeley High School, Hartford, Conn. PROFESSOR ALFRED L. PEIKER, of Trinity College, spoke on "The Catalytic Effect of Acids on the Hydrolysis of Hydrogen Cyanide," and PROFESSOR K. S. BUXTON, of the same institution, gave an address on "Modern Ideas of Atomic Structure."

Parke, Davis & Company. GEORGE S. DAVIS, one of the men to whom this company owes its corporate name, died on October 1st, at the age of 85 years. Mr. Davis, whose activities were influential in the expansion of the company during the first quarter century of its existence, had retired from active business life more than thirty years ago.

A native of Detroit, Mr. Davis began his business career as a clerk in a retail drug store. Later he engaged in the wholesale drug business and in 1867 he became associated with the pharmaceutical manufacturing concern of Duffield, Parke & Co. In 1871 DR. DUFFIELD retired from the company and the firm name became Parke, Davis & Co., with Mr. Davis as its general manager.

Sioux Valley Chemists Club. The Sioux Valley Chemists Club held its first meeting of the year at Yankton, South Dakota, in September. DEAN L. E. AKELEY, of the University of South Dakota, addressed the gathering.

Following the address, the members were conducted through Forbes Hall, the new science building of Yankton College. This building houses the chemistry, physics, and biology departments and is modern in every respect.

The October meeting of the club was held in Sioux City.

Thirteenth Exposition of Chemical Industries. Plans for the 13th Exposition of Chemical Industries, which will be held at the Grand Central Palace, New York, during the week of May 4, 1931, are in progress and rapidly taking shape. During the past summer preparatory work has been done in connection with the Students Course of Lectures and plans are now being laid for it. The course will this year again be under the chairmanship of PROF. W. T. READ, dean of chemistry at Rutgers University, and he wishes to make the following appeal to the colleges and universities and others interested.

"Experience of the 1929 course has indicated that a change of policy is necessary, in order to enable college students to attend such courses toward the close of the college year. The previous fall days found most colleges and universities either on the eve of opening or having been open such a short time that the few days lost from the campus were not a serious matter, but with the exposition coming early in May, near the close of the academic year when reviews are under way and final examinations are in sight, it is difficult for any institution to give students of chemistry and chemical engineering a full week at the exposition, and the previous system of two parallel courses of six days each, one for elementary and one for advanced students has been changed. Instead there will be three successive courses of two days each. One course will cover the elements of chemical engineering equipment, and the more important types of apparatus with which chemical engineering operations are carried out. Following this will be a two-days advanced course dealing with the more specialized equipment of recent development in various fields, reviews of research which have marked advances from the theory and principles of chemical engineering. The third course will deal with the new materials and processes of chemical industry, due emphasis being placed on chemical theories and principles rather than equipment, and also with significant topics of chemical economics.

"The regular course for students will be concluded at noon the last day of the exposition. On Saturday afternoon an invitation is extended to high-school, college, and university teachers to hear a series of lectures on the teaching value of the exposition, which will be followed by a personally conducted tour to illustrate the material of the lectures.

"While the list of speakers for this series is not complete, those in charge of the institutional part of the exposition plan to secure a group of lecturers who are recognized authorities in their fields as well as men who can get their ideas across to the students. The previous courses have been very fortunate in having a very able staff of lecturers and the 1931 course is expected to maintain this high standard.

"Although there are some seven months until the next exposition opens its doors, plans for the whole academic year are now being made at every college and university. Teachers of chemistry and chemical engineering are urged to arrange now for extra lectures and reviews in advance, in order that their students may be able to attend the particular course which their training indicates they should need."

Already there are about three hundred exhibitors who have reserved space for the forthcoming exposition, so that even at this early date prospects for an excellent exposition are very good.

The advisory committee of the exposition includes DR. ARTHUR D. LITTLE, *Chairman*, RAYMOND F. BACON, L. H. BAEKELAND, J. V. N. DORR, LAMMOT DU PONT, HENRY B. FABER, MOSES GOMBERG, WILLIAM HAYNES, CHARLES H.

HERTY, H. E. HOWE, LOUIS KAHLENBERG, SIDNEY KIRKPATRICK, FRED W. PAYNE, W. T. READ, CHARLES F. ROTH, L. V. REDMAN, H. J. SCHNELL, R. GORDON WALKER, A. H. WHITE, DAVID WESSON, M. C. WHITAKER, T. B. WAGNER and VICTOR WILLIAMS.

U. S. Geological Survey. *Science* announces that R. C. WELLS has been appointed chief chemist in charge of the division of chemistry and physics, geologic branch, and that GEORGE STEIGER, former chief, will return to studies in chemical and spectroscopic analysis.

Vocational Education in Porto Rico. *School and Society* reports that a study of the need of vocational education in Porto Rico will be made by the director of the Federal Board for Vocational Education, MR. J. C. WRIGHT, upon the request of GOVERNOR THEODORE ROOSEVELT. "On leaving for Porto Rico on October 14th Dr. Wright stated to a representative of the *U. S. Daily* that his survey will involve such educational matters as received principal emphasis in the annual report of the governor.

"Governor Roosevelt recommends that the activities for vocational education by the federal government be extended to Porto Rico. His report called attention to the inadequacy of the school facilities. With a school population of 500,000, the public schools can accommodate only 220,000.

"An attempt will be made to develop a consolidated vocational school so that the boys and girls can be trained for useful occupations.

"Of the 1000 high-school graduates who annually receive diplomas, the governor states that 95 per cent take scientific training and 5 per cent commercial training. These graduates are unable to procure work after leaving high school.

"The governor recommends better cooperative facilities between the United States and Porto Rico in meeting the problem of unemployment.

"It is expected that from the survey and exchange of ideas on vocational education, some definite plan for relief from the educational aspects will be worked out. The precise policies will await the survey, which will commence immediately upon the arrival of Dr. Wright. The chief of the industrial education service, FRANK CUSHMAN, will accompany the director and will assist in making the survey."

EDUCATIONAL INSTITUTIONS

Bucknell University, Lewisburg, Pa. MESSRS. KENNETH B. ANDRUS and RICHARD A. NAGEL, both of Elmira, N. Y., and senior chemical engineering students of Bucknell University, have been awarded Bloede Scholarships granted through the Scholarship Committee of the Chemists Club of New York City. These awards carry a stipend of $500 and are given by DR. VICTOR G. BLOEDE, Carroll Station, Baltimore, Md., to worthy students who have attained high scholastic achievement and have shown aptitude for investigational work.

Carnegie Institute of Technology, Pittsburgh, Penna. DR. ERIC K. RIDEAL, professor of colloidal physics at the University of Cambridge, gave two public lectures at Carnegie Institute of Technology, October 9 and 10, 1930. The subject of Dr. Rideal's lectures was: "Monomolecular Films."

Columbia University, New York City. DR. HENRY C. SHERMAN, Mitchill professor of chemistry in Columbia University, lectured on the chemistry of nutrition, July 7th–25th, at the State College of Oregon; July 31st, at the University of Washington; and Aug. 6th, at the University of Wyoming.

Prof. Sherman was granted a short leave of absence to speak to the graduate seminar in chemistry at Yale on October 22nd; to address the New England Den-

tal Society and to deliver the Forsythe lecture in Boston, October 23rd; to report as chairman of the Committee on Nutritional Problems to the American Public Health Association at its annual meeting at Fort Worth on October 29th, and to address the Oklahoma, Kansas, and Nebraska Sections of the A. C. S. on October 30th, November 4th, and November 6th, respectively.

PROFESSOR MARSTON T. BOGERT has just returned from an absence of several months in Europe, during which time he attended the tenth annual meeting of the Society of Chemical Industry of France at Liège, Belgium, September 6th to 13th, on which occasion he represented the following organizations: American Chemical Society, American Association for the Advancement of Science, American Philosophical Society, and the American Pharmaceutical Association.

At the closing session of the meeting Professor Bogert was elected an honorary member of the Society.

The following week, September 7th to 20th, the tenth meeting of the International Union of Chemistry took place likewise at Liège, and Professor Bogert attended as a member of its council and as the representative of the National Academy of Sciences and of the National Research Council.

Four new instructors have been appointed in chemistry. They are: DR. CHARLES O. BECKMANN, DR. LELA E. BOOHER, MR. IRVING A. COWPERTHWAITE, and MR. SAMUEL B. ELLIS.

Dr. Beckmann has returned from a year of study with PROFESSORS FAJANS and SOMMERFELD at Münich, where he devoted his time to ionic refractivities and theoretical physics.

J. J. BEAVER, assistant professor of chemistry at Columbia University, has just returned from a year spent in Europe as a Cutting Fellow. Nine months were spent at PROFESSOR BODENSTEIN'S laboratory in Berlin working on the kinetics of the decomposition of chlorine monoxide. About six weeks were spent in Münich attending the lectures of PROFESSOR FAJANS. A short course given at Jena by members of the Zeiss scientific staff on the design and use of optical apparatus proved to be interesting and valuable. In addition Professor Beaver visited the laboratories at Göttingen, Leipzig, Heidelberg, Zürich, Utrecht, Amsterdam, London, Cambridge, and Edinburgh.

On October 16th, PROFESSOR V. K. LAMER and MR. IRVING A. COWPERTHWAITE presented a paper at the Chemistry Research Club, New York, on "Thermodynamic Properties of Zinc Sulfate and the Theory of Complete Dissociation."

School and Society has announced a series of three lectures scheduled for November 10th, 12th, and 14th, at Teachers' College, Columbia University, under the auspices of the Julius and Rosa Sachs Foundation by PROFESSOR CARL H. BECKER of the University of Berlin and Minister of Education in Prussia (1919–1930). The three lectures discussed: The Present Education Situation in Germany; The New Program of Secondary Education in Germany; and Character and Aims of the New German Teacher-Training Program.

Cooper Union, New York City. A new course in modern physics is being presented on Tuesday evenings by PROFESSOR KARL F. HERZFELD of The Johns Hopkins University. The course, which was enthusiastically received at its opening on October 7th, has an enrolment of over three hundred. Among those taking the series of lectures are a number of representatives from the staffs of various universities and colleges, and a large number of scientists from the industry. The present group of lectures is on the subject of Crystal Structure.

PROFESSOR ALBERT B. NEWMAN, head of the department of chemical engineering of Cooper Union, started a series of lectures on the Unit Operations of Chemical Engineering on Monday evening, October 20th. This course, which is being presented evenings for the first time, has an

enrolment of about a hundred and twenty-five, among whom are many men from industry.

MR. ALLEN L. TARR has resigned from his position as metallurgist at the Philadelphia plant of the General Electric Company to join the instructing staff of the department of chemical engineering at Cooper Union, where he will specialize in metallurgy. Mr. Tarr was previously connected with the mining and metallurgical staff of Massachusetts Institute of Technology.

An article on the Minimum Voltage to Reduce Aluminum Oxide by PROFESSOR ALBERT B. NEWMAN, of Cooper Union, and PROFESSOR GEORGE G. BROWN, of the University of Michigan, has just been published by the latter institution.

Cornell University, Ithaca, N. Y. Announcement has been made of the names of those who have accepted appointment to the George Fisher Baker Non-Resident Lectureship in Chemistry at Cornell University for the next four years. They are:

First term, 1930–31, PROFESSOR G. HEVESY, University of Freiburg, Germany; Second term, 1930–31, DR. N. V. SIDGWICK, Lincoln College, Oxford, England; First term, 1931–32, PROFESSOR W. L. BRAGG, University of Manchester, England; Second term, 1931–32, PROFESSOR ALFRED STOCK, Technische Hochschule, Karlsruhe, Germany.

First term, 1932–33, PROFESSOR CECIL H. DESCH, Sheffield, England; Second term, 1932–33, PROFESSOR OTTO HAHN, Kaiser Wilhelm Institut für Chemie, Berlin-Dahlem, Germany; First term, 1933–34, PROFESSOR V. M. GOLDSCHMIDT, Göttingen, Germany; Second term, 1933–34, PROFESSOR ROBERT ROBINSON, Oxford, England.

Denison University, Granville, Ohio. DR. W. C. EBAUGH, professor of chemistry at Denison University, is spending the year as visiting professor of chemistry at Robert College, Constantinople.

MISS MATTIE TIPPET (M.S., University of Chicago) is serving as assistant professor at Denison, assisting PROFESSOR W. A. EVERHART, (Ph.D., Ohio State University), acting head of the department.

The Johns Hopkins University, Baltimore, Md. The addition of eight new fellowships to the National Fellowship Plan of the department of chemistry was announced by PRESIDENT JOSEPH S. AMES at the second annual conference of donors to the plan, which was held at the university on November 7th. THE COCA COLA COMPANY, Atlanta, Georgia; G. A. PFEIFFER, New York City; and the CENTRAL SCIENTIFIC COMPANY, Chicago, Illinois, have each contributed one fellowship; three have been given by the AMERICAN CAN COMPANY, New York City, and two, which may be assigned to any state at the discretion of the chemistry department, have been donated by THE CHEMICAL FOUNDATION, New York City.

Two additional fellowships-at-large, contributed by FRANCIS P. GARVAN, who endowed the Chair of Chemical Education under which the National Fellowship Plan is operating, will also shortly be put into effect.

This announcement was made by President Ames in the course of introducing to the conference DR. ARTHUR D. LITTLE of A. D. Little & Co., Boston, who gave an address on "Leadership" at the evening session. Dr. Little's address, which was the second lecture of the Dohme Foundation series for the year 1930–31, was followed by a sound screen production by the Radio Corporation of America of a Dohme lecture by DR. ROBERT A. MILLIKAN, of the California Institute of Technology, on "Cosmic Ray."

Other features of the conference sessions were as follows:

10.00 A.M. Welcome by PRESIDENT JOSEPH S. AMES.

10.30 A.M. Conference to discuss the conditions for the annual renewal of fellowships.

(*a*) Should the selected student be required to hold a record superior to any

other student from the state in which the fellowship is given? *Leader of discussion:* C. G. CAMPBELL, president, Kewaunee Manufacturing Company, Kewaunee, Wis.

(*b*) Should the selected student be required to hold a record superior to any other student in the department who does not hold a fellowship? *Leader of discussion:* H. A. B. DUNNING, president, Hynson, Westcott and Dunning, Baltimore, Md.

11.30 A.M. Visit to the research laboratories of the chemistry department.

12.30 A.M. Luncheon for the donors, faculty, and fellowship students.

2.00 P.M. Conference on the selection, education, and testing of students who possess creative ability.

(*a*) Selection—Improvement in the methods of selection now in use. *Leader of discussion:* MARTIN MATHESON, director, John Wiley and Sons, Inc., New York City.

(*b*) Education—Policies of chemistry department aimed at developing creative ability. *Leader of discussion:* J. C. W. FRAZER, chairman, chemistry department.

(*c*) Tests—To devise an annual test for measuring the student's growth in creative ability. *Leaders of discussion:* F. O. CLEMENTS, director of research, General Motors Corporation, Detroit, Mich.; A. A. BACKHAUS, vice-president, U. S. Industrial Alcohol Company, Baltimore, Md.

6.00 P.M. President's dinner to donors and their wives.

Besides those mentioned in the program, the following donors or their representatives also attended the conference, accompanied by their wives: DR. M. A. STINE, representing the E. I. du Pont de Nemours & Co., Wilmington, Del.; ELI LILLY, for the Eli Lilly Company, Indianapolis, Indiana; S. L. REDMAN, for the Central Scientific Company, Chicago, Illinois; GEORGE O. CURME, JR., for the Carbide and Carbon Chemicals Corporation, New York City; J. T. BAKER, of the J. T. Baker Chemical Co., Phillipsburg, N. J.; R. E. LEE, for the Fleischmann Company, New York City; F. F. FITZGERALD, for the American Can Company, New York City; W. P. HEATH, representing the Coca Cola Company, Atlanta, Georgia; E. B. BABCOCK, for the Firestone Tire and Rubber Co., Akron, Ohio; and DR. WALTER A. PATRICK, of The Johns Hopkins University.

Dr. A. R. L. DOHME, who established the Dohme lectureship by which prominent scientists are invited to lecture at the university for the National Fellowship men and other students, was also present at the conference.

The following members of The Johns Hopkins University faculty attended the National Fellowship conference sessions: DR. D. H. ANDREWS, DR. F. O. RICE, DR. KARL F. HERZFELD, DR. N. E. GORDON, DR. G. H. CARTLEDGE, DR. E. E. REID, and DR. W. M. THORNTON, JR.

Marquette University, Milwaukee, Wisconsin. PROFESSOR GEORGE A. HERRMANN recently completed a series of five weekly radio talks over the Marquette University Radio Station WHAD. His general topic, "Chats on Food Products," was divided into the following subdivisions: "The Production of Foods," "Foods and Their Function," "The Preservation of Foods," "The Adulteration of Foods" and "Labels on Food Containers."

Professor Herrmann also addressed the Botany Club of Marquette University at their first formal meeting and discussed the topic "Drug-Bearing Plants." He supplemented his discussion with specimens taken from his pharmacognosy collection of crude drugs, which contains more than 400 samples.

The Marquette Chemical Society held its first formal meeting recently and featured a three-reel film entitled "The Story of Asbestos," furnished through the courtesy of the U. S. Department of Commerce. At their next meeting another film will be shown, featuring "Oxygen, the Wonder Worker."

Mellon Institute of Industrial Research Pittsburgh, Pa. DR. LAWRENCE W.

BASS, of this institute, spoke on "The Scientific Method and Its Application in Industry," on October 23rd before DR. CHARLES REITELL'S class in scientific management in the extension division of the University of Pittsburgh at Erie, Pa. This course of lectures is being sponsored by the Erie Chapter of the National Association of Cost Accountants.

Millsaps College, Jackson, Miss. MR. J. B. PRICE has recently been appointed as assistant professor of chemistry in Millsaps College. After graduation from Millsaps with the M.S. degree and after teaching one year, Mr. Price was appointed student laboratory assistant at the University of Mississippi, where he did graduate work and received the M.S. degree.

Missouri School of Mines and Metallurgy, Rolla, Mo. The Ira Remsen Society, composed of chemical engineering students at the School of Mines and Metallurgy of the University of Missouri, held its organization meeting on October 15th, with the largest organization attendance since the chapter was formed. G. F. TRABAND was elected president; R. G. HOLMES, vice-president; and H. P. OEHLER, secretary and treasurer. The chapter will meet on the first and third Wednesday of each month. Speakers so far arranged for include DR. JOHN H. GARDNER, associate professor of chemistry, Washington University, St. Louis; H. EDMUND WIEDMANN, consulting chemical engineer, St. Louis; PROF. LEONARD F. YNTEMA of the chemistry department of St. Louis University; CHAS. W. CUNO, consulting chemical engineer, St. Louis; and DR. LAWRENCE P. HALL, research chemist, Mallinckrodt Chemical Works, St. Louis. Mr. Wiedemann will talk on December 3rd.

An unusual increase in enrolment in the School of Mines and Metallurgy is reported from the registrar's office, the registration totaling 598 this year as compared with 520 for the first semester of last year, an increase of 15 per cent.

CHAS. J. POTTER, a graduate student at the School of Mines and Metallurgy last year, has accepted one of the Jones fellowships at the University of West Virginia, his research problem covering the carbonization of West Virginia coals.

Northeastern University, Boston, Mass. One hundred and seventeen members of the sophomore class are enrolled in the chemical engineering curriculum under the recently inaugurated five-year cooperative plan, giving the university one of the largest total enrolments in this particular course of any school in the country.

Several members of the class of 1930 are now engaged in chemical engineering graduate work, including J. C. GALE and H. L. VORDEREI, who are studying at the Massachusetts Institute of Technology, and A. W. MORANG, E. E. TANSEY, M. VORELSANG and S. ZUFFANTI, who are attending Boston University.

ASSOCIATE PROFESSOR CHESTER P. BAKER has been promoted to assistant professor of chemical engineering. Professor Baker is a graduate of Northeastern (class of 1920), and has pursued graduate work at the Massachusetts Institute of Technology and Boston University, having received his master's degree from the latter institution.

MR. SAVERIO ZUFFANTI, Northeastern '30, has been appointed instructor of chemical engineering.

MR. JOHN C. MORGAN, another new member of the faculty, is coördinator of chemical engineering students in the department of coöperative work. Mr. Morgan is a graduate of the University of New Hampshire (class of 1913).

The Ohio State University, Columbus, Ohio. The Columbus Section of the A. C. S. had its two hundredth meeting during November.

The December 11th meeting of the Columbus Section will be held at the Battelle Memorial Institute, with the Institute acting as host. MR. M. A. GROSSMAN of the research laboratories of the

Republic Steel Corporation will address the group on "Oxygen in Steel." The January meeting will be addressed by MR. CHARLES E. BILLS, director of the research laboratories of the Mead Johnson and Company of Evansville, Indiana. His subject will be "Ergosterol."

MR. ROBERT SCHOENLAUB (B.S., Cer. Engr., O. S. U., 1930) is the new graduate assistant in the department of mineralogy.

During November PROFESSOR FRANK R. VAN HORN, of the Case School of Applied Science, gave two lectures on the recently discovered platinum deposits in hard rock. During the past year Professor Van Horn has been in South Africa visiting the diamond mines, the new platinum deposit region and other places of interest. All previously known platinum mines were in sand deposits.

PROFESSOR MAX VON LAUE, director of the Institute for Theoretical Physics in the University of Berlin, and PROFESSOR RICHARD LADENBURG, also of the University of Berlin, addressed the chemists and physicists on October 13th. Their respective subjects were "Diffraction of X-Rays and Electrons" and "The Intensity of Spectral Lines."

The following have recently been added to the staff in the office of *Chemical Abstracts:* MISS M. AUDREY DUDLEY (A.B., Queen's University); MISS LEONA PENCE (A.B., O. S. U.); and MISS GERTRUDE GIBBONS (A.M., O. S. U.).

MR. KERMIT GROVES is junior research assistant with the Experiment Station and is working on "Foaming and Priming of Boiler Water at High Pressure." The investigation is under the direction of PROFESSOR C. W. FOULK of the department of chemistry.

MR. S. J. SIMPKINS (M.A. in chemistry, 1930) is now with the research department of the Vacuum Oil Company at Paulsboro, N. J.

The following scholarships and fellowships have been awarded in the department of chemistry for the present academic year: ALFRED L. CURL (du Pont Fellow); FRANTISEK CUTA of the University of Prague (University Fellow); JULIAN M. MAVITY (University Fellow); MARJORY K. WALKER (University Fellow).

PROFESSOR JAMES R. WITHROW, of the department of chemical engineering, has been re-elected as a member of the assembly of the American Engineering Council.

MR. ROBERT KINTNER, professor of chemistry at the Rose Polytechnic Institute for the past year, has returned to complete his work for the Ph.D. degree in chemical engineering.

MR. LYLE K. HERNDON (B.Ch.E.) is now a chemical engineer with the State Water Commission of Charleston, West Virginia. MR. JOHN C. PEW (M.Sc., Ch.E., 1930) is employed by the U. S. Department of Agriculture at the Forest Products Laboratories, Madison, Wisconsin. MR. FREDERICK L. WAY (B.Ch.E., 1928) is at present chief chemist with the Freedom Oil Works of Freedom, Pa.

Pennsylvania State College, State College, Pa. The fifth annual Priestley Lectures, under the auspices of the department of chemistry of this institution and in coöperation with the department of electrical engineering, were given by DR. JOHN W. WILLIAMS, assistant professor of chemistry of the University of Wisconsin, on November 10th, 11th, 12th, 13th, and 14th on "The Relation between Physical Chemistry and Electrical Engineering."

The subject of the individual lectures were as follows: The Structure of Molecules as Revealed by Dielectric Constant Studies; The Orientation of Molecules in an Alternating Electrical Field; The Interionic Attraction Theory of Electrical Conductance; The Relation of Conductance and Dielectric Constant Theory to the Problem of Dielectric Loss; The Interionic Attraction Theory of Viscosity—Its Possible Application to Colloidal Systems.

DR. ERIC K. RIDEAL, professor of physical chemistry, Cambridge University, England, was the speaker at the 35th meeting of the Central Pennsylvania Section of

the A. C. S. on October 8th. Dr. Rideal's subject was "Recent Research on Films."

THE HONORABLE JAMES M. DAVIS, Secretary of Labor, Washington, D. C., gave an address on "Conservation and Its Importance to Humanity," at the recent Conservation Congress sponsored by the Department of Nature Study and presented as a part of the Seventy-fifth Anniversary Celebration of The Pennsylvania State College. The program included twelve speakers in addition to Secretary Davis and a large number of people interested in this field attended the Congress.

At this Seventy-Fifth Anniversary Celebration, held October 23rd, 24th, and 25th, GOVERNOR JOHN S. FISHER formally presented twelve new buildings which have been erected during the extensive building program of the past two years. This constitutes a forward step unprecedented in the history of the college. On Thursday, October 23rd, known as "Education Day," "Admission Problems in Pennsylvania Colleges," and "Personnel Practices" were discussed by leading educational administrators of the state. PRESIDENT-EMERITUS WILLIAM O. THOMPSON, of Ohio State University, gave the principal address, entitled "The Land Grant Colleges." PRESIDENT HENRY W. A. HANSON, of Gettysburg College presented greetings from the colleges of Pennsylvania. DR. JAMES N. RULE, deputy superintendent of public instruction, represented the State Department of Public Instruction and PROF. JOHN H. TYSON, principal of Upper Darby Township High School, represented the secondary schools of the state. On Saturday, the "Alumni Home Coming Day," the chief event was the dedication of the newly constructed Old Main Building. [See J. CHEM. EDUC., **7**, 513, 515 (March, 1930).] Throughout the history of the college Old Main Building has been the center of activities and it is very gratifying to the alumni to see the old building reconstructed along modern lines and beautifully furnished throughout.

Princeton University, Princeton, N. J. A club or common room, situated on the top floor of the Frick Chemical Laboratory, intended for recreation and for informal meetings of graduate students and faculty, was formally opened on Monday evening, September 29, 1930. A general discussion was held on "The Mechanism of the Oxygen-Hydrogen Reaction," after which refreshments were served.

At the first meeting of the Chemical Club for this school year, held on Friday evening, Oct. 17, 1930, PROF. E. K. RIDEAL, of the University of Cambridge, lectured on "Some Aspects of Thin Films."

Officers of the Chemical Club for the present school year (1930–1931) include T. J. WEBB, president; A. T. WILLIAMSON, secretary; and K. B. MCALPINE, treasurer.

An announcement in *Science* states that DR. EUGENE PACSU, formerly a member of the faculty of the University of Budapest, has become assistant professor of chemistry at Princeton.

Rice Institute, Houston, Texas. *Science* announces that DR. WALTER R. KIRNER, assistant professor of organic chemistry at the Rice Institute, has returned from a sabbatical year spent in study in Europe. During the year he worked at the University of Graz in Austria, studying the technic of micro-organic analysis under PROFESSOR FRITZ PREGL. The complete apparatus for organic micro-analysis has been purchased for the Rice Institute. Dr. Kirner also spent some time in research in PROFESSOR HEINRICH WIELAND'S laboratory in the University of Munich and with PROFESSOR ROBERT ROBINSON at the University College of London.

St. Bonaventure's College and Seminary, St. Bonaventure, New York. MR. W. R. SHAW, of Bradford, Pennsylvania, field representative of the Pennsylvania Grade Crude Oil Association, has donated a Pennsylvania Grade Oil Refining Exhibit to the department of chemistry. The exhibit consists of a flow sheet with

32 samples, each representing the oil at a particular stage of the process. The flow sheet is so arranged that the sample bottles may be mounted in their respective places on the sheet.

MR. THOMAS J. HARKINS (B.S., 1929), a graduate student candidate for the M.S. degree, has been appointed an assistant in the department.

The Board of Regents of New York State on December 19th last granted permission to St. Bonaventure College to confer the advanced degrees of M.S., M.A., Ph.D., D.Sc. upon candidates who have successfully pursued a comprehensive program of graduate studies and received the recommendation of the faculty.

With completion of an experimental still for petroleum refining studies, the petroleum chemistry laboratory will be enabled to widen the scope of its investigation and experimental studies on refining. The course in petroleum chemistry and refining which last year was a one-semester course is to be this year enlarged to a full year's work. The course is given at 7.30 on Tuesday and Thursday evenings and is in charge of PROFESSOR H. J. TORMEY.

A new course in "Petroleum Geology and Production" is to be added to the curriculum of the petroleum engineering school and will be offered this year. The course will be given evenings and will be in charge of MR. PAUL TORREY, petroleum geologist and engineer of Bradford, Pa. Mr. Torrey was formerly associated with U. S. Geological Survey and is a recognized authority on petroleum geology and production, particularly in the Bradford and Alleghany fields.

State University of Iowa, Iowa City, Iowa. ADOLF H. KUNZ (Ph.D., 1928) has accepted an assistant professorship in chemistry at the University of Oregon, Eugene, Oregon. Dr. Kunz has been with the du Pont Ammonia Corporation at Wilmington, Del.

DR. and MRS. LOUIS WALDBAUER returned to the university on September 18th, after spending the summer in England and Germany.

The Second Annual Conference of Science Teachers was held at the University on October 16th, 17th, and 18th. PROF. H. G. DEMING of the University of Nebraska gave an address before the chemistry section.

The new graduate assistants in the chemistry department are: RAYMOND L. ALBROOK (B.A., University of Iowa); W. N. BAKER (B.A., Morningside College); ELIZABETH M. BRADWAY (M.A., University of Oregon); M. A. BUCHANAN (B.A., Illinois College); BYRON B. CLARK (B.A., Baylor University); ARTHUR C. HANSON (B.S., Buena Vista College); GERALD O. INMAN (B.S., University of Iowa); DUANE C. MCCANN (B.A., University of Iowa); and ROY D. MAXWELL (B.A., Oklahoma City University).

ROBERT W. MCLACHLAN (M.S., Iowa, 1927), who has been teaching at Illinois College, is a graduate fellow in the chemistry department for the year 1930–31.

W. W. FLOYD (M.A., Texas) holds a graduate fellowship in physical chemistry.

The following hold scholarships for the academic year 1930–31: PATRICK H. DOUGHERTY (B.S., Iowa); WILLIAM H. JOHNSON (B.A., Carthage College); ARTHUR F. NELSON (B.A., St. Olaf College); JAMES W. NEWSOME (B.S., Iowa); and JOHN HOWE SCOTT (B.A., Clark University).

University of Denver, Denver, Colo. *Science* reports that DR. R. G. GUSTAVSON, professor of chemistry at the University of Denver, has returned after a year's leave of absence during which he taught and engaged in research at the University of Chicago. Professor Gustavson is continuing at Denver his experiments with the sex hormone.

University of Nevada, Reno, Nevada. On the evening of September 13th, the Sacramento Section of the A. C. S. held its 62nd regular meeting in Reno at the new Mackay Science Hall of the Univer-

sity of Nevada. PROF. S. A. LOUGH, University of Nevada, presented a paper on "Mercapturic Acid Synthesis in the Rabbit," MR. EDMUND S. LEAVER, superintendent, Rare and Precious Metals Station, U. S. Bureau of Mines, discussed "The Effect of Alkalinity Due to Lime on the Recovery of Gold by Flotation," and PROF. J. H. NORTON of the Sacramento Junior College delightfully entertained with a talk on "Doctor Wiley and His Works." After the meeting the visitors made a tour of the building and were received by members of the University of Nevada chemistry club in the library and seminar rooms.

On the evening of October 11th, the Sacramento Section held its 63rd regular meeting at the Sacramento Junior College. Two papers were presented. DR. MAXWELL ADAMS, vice-president of the University of Nevada, reviewed the general subject of "Essential Oils," and DR. S. S. KISTLER, of the College of the Pacific, spoke on the topic, "An American Student in Europe," and furnished his audience with enlightenment and entertainment. Furthermore, two reels of motion pictures from the U. S. Bureau of Mines, "The Story of Sulphur," served to round out what proved to be a highly interesting program.

DR. MERYL W. DEMING, of the department of chemistry of the University of Nevada, has been promoted to the rank of assistant professor.

University of New Hampshire, Durham, N. H. *Science* states that DR. JAMES A. FUNKHOUSER, former instructor in organic chemistry at The Ohio State University, is now assistant professor of chemistry at the University of New Hampshire.

University of Pennsylvania, Philadelphia, Penna. *Science Service* announces the 165th anniversary of the University of Pennsylvania Medical School which occurred in October. It states, "America has been producing her own doctors for 165 years. Ten years before the Revolution, two young doctors of this city, who had had to go to Scotland for their own medical training, founded the first medical school in our country. The young doctors were JOHN MORGAN and WILLIAM SHIPPEN, JR. Each later served for a period as Medical Director-General of the American Army. The school they founded is the University of Pennsylvania Medical School. . . . Besides Morgan and Shippen, the first faculty included ADAM KUHN of Germantown and BENJAMIN RUSH, one of the signers of the Declaration of Independence. These men and those who followed them helped to make medical history in the United States.

"The school started in a wooden building known as Surgeon's Hall. It progressed from there to some rooms in the mansion built by the State of Pennsylvania for George Washington. Now it occupies its own modern buildings where every kind of equipment for teaching and practicing medicine is at hand."

The development of the medical clinic of today was discussed at this celebration by PROF. WILLIAM H. WELCH of The Johns Hopkins University School of Medicine. PROF. A. V. HILL, distinguished English biophysicist, and SIR WALTER M. FLETCHER, who has played an important rôle in the organization and development of medical research in Great Britain, also spoke.

University of Pittsburgh, Pittsburgh, Pa. DR. ALEXANDER LOWY was recently elected to the board of managers of the American Electrochemical Society. He attended the meeting of the society at Detroit on September 25, 1930.

DR. A. L. ROBINSON has returned to the university after a year as Exchange Fellow of the Institute of International Education at the University of Munich. He was engaged in post-doctorate study with DR. LANGE on "Heats of Dilution of Strong Electrolytes." DR. HANS DU MONT, Griefswald, Germany, Exchange Fellow of the Institute of International Education at the University of Pittsburgh

last year, is now studying at Yale University. DR. WALTER FEITKNICHT, of the University of Basle, is Exchange Fellow of the Institute of International Education at the University of Pittsburgh this year.

DR. ALEXANDER SILVERMAN, head of the department of chemistry, returned from Europe on October 12th after a two months' visit to Belgium and France. In Belgium, Dr. Silverman was a delegate to the Tenth Congress of Industrial Chemistry and to the International Union of Pure and Applied Chemistry. At the former he delivered an illustrated address on "Recent Developments in American Glass Manufacture." Dr. Silverman made a study of educational and research institutions and the museums of both countries. He has purchased about a dozen new masterpieces in the field of glass art to be placed in the museum at the university.

DR. WILLIAM H. MCPHERSON, president of the A. C. S., addressed the Pittsburgh local section on September 25, 1930. The subject of his address was "The Methods of Nature." He discussed laboratory attempts to reproduce the methods which nature employs for synthesizing substances found in the growing organism.

University of Texas, Austin, Texas. This university, it is announced in *School and Society*, is collaborating with the University of Mexico in plans for an annual exchange of students and instructors. MR. E. D. FARMER, a rancher of Texas, has given $205,000 to the state university to finance the exchange, and the legislature has approved the gift. The interest on this money will support eight student scholarships of $1000 each and also provide for four exchange professors each year.

The University of Tulsa, Tulsa, Okla. The department of chemistry is occupying new quarters this year. The entire top floor of the new Waite Phillips' Engineering Building is devoted to chemistry. This space contains three laboratories, a classroom, a stockroom, and two private offices and laboratories. All laboratory tables are surfaced with alberene stone and all sinks and drain troughs are constructed of the same material.

The general chemistry and qualitative analysis laboratory contains accommodations for 144 students. Thirty-two students can work very comfortably at one time. In case of need, forty-eight can be handled in one section. Ample hoods, with individual exhaust fans and motors, are provided.

Work in quantitative analysis and that in physical chemistry are given in the same laboratory. Here are located individual lockers for 44 students. There is also drawer and cabinet space for permanent or special pieces of equipment needed in physical chemistry. Balances are housed in individual compartments of a wall case and shelf. Individual lighting is provided.

The third laboratory is designed for organic chemistry. Two 20-foot tables provide roomy lockers for 24 students. A well-ventilated and exceptionally well-lighted hood, measuring $18 \times 8 \times 2\frac{1}{2}$ feet, gives grounds for the hope that fumes will not be too evident in this room. Additional items are a combustion table and a display case for student preparations.

In addition to the classroom on the top floor, there is a lecture room on the main floor seating 100 students. This is provided with a well-equipped demonstration table.

RICHARD LUKINS, a graduate of the university last June, is now a student at Massachusetts Institute of Technology. He is taking special work in chemical engineering.

University of Wisconsin, Madison, Wis. The *Journal of Higher Education* announces that the University of Wisconsin has established recently an Alumni Research Foundation which will exploit all salable scientific developments by mem-

bers of the staff of the university. Under the direction of HARRY L. RUSSELL, former dean of the College of Agriculture, Wisconsin scientific developments will be patented and put upon the market. The funds thus raised will be used to finance the scientific work of the university.

Washington University, St. Louis, Mo. PROFESSOR L. MCMASTER, DR. L. E. STOUT, DR. T. R. BALL, DR. J. H. GARDNER, and MR. S. S. COOPER attended the fall meeting of the A. C. S. in Cincinnati. Dr. McMaster is a member of the Senate of Chemical Education and Dr. Gardner is councilor for the St. Louis Section. Ten of the papers presented at this meeting were given by members of the staff and former graduate students.

DR. H. E. VAN NORMAN, director of research and public relations of The Borden Company, visited the department during the National Dairy Show held in St. Louis, October 13th–18th.

DR. HELLMUT SIEBOURG of the University of Cologne is, through the Institute of International Education, an exchange graduate student in the department.

Evening courses conducted this semester are: general chemistry by DR. L. MCMASTER and MR. C. A. NAYLOR; qualitative analysis by DR. L. E. STOUT; organic chemistry by MR. A. E. GOLDSTEIN; and colloid chemistry by DR. H. L. WARD. A new course on the determination of hydrogen ions and potentiometric titrations is also being given by DR. T. R. BALL. It is open only to students who have had a course in physical chemistry.

Considerable new equipment has been added to the laboratories of chemical engineering and physical chemistry. Among these additions is a complete equipment for temperature measurements by means of a platinum resistance thermometer.

West Virginia University, Morgantown, W. Va. The Kanawha Valley Section of the A. C. S. is sponsoring the night school courses in beginner's college chemistry being conducted at the Charleston Senior High School this year. The courses are under the direction and supervision of the chemistry department of West Virginia University. The classes are held from 7.00 to 9.00 P.M. on two nights each week.

Full college credit of four semester hours will be given by West Virginia University to those satisfactorily completing the course, provided sufficient high-school credit for university entrance is held.

Western Reserve University, Cleveland, Ohio. *Science* has announced that the twenty-third Hanna Lecture was delivered at the School of Medicine of this university on September 25th by PROFESSOR FRANZ KNOOP, professor of physiological chemistry at the University of Tübingen, on "The Significance of the Intermediary Metabolism." This was followed on September 26th by a second lecture, reviewing informally the speaker's work on beta-oxidation.

Yale University, New Haven, Conn. Two new instructors have been appointed in the department of chemistry, BENTON BROOKS OWEN (Ph.D., Yale, 1930) and GEORGE E. P. SMITH, JR. (Ph.D., Stanford, 1930). Dr. Owen will be in charge of the course in qualitative analysis and Dr. Smith will teach general chemistry. DR. HANS DU MONT of the University of Greifswald, an International Exchange student at the University of Pittsburgh in 1929–30, has been made the A. Homer Smith chemistry fellow and DR. SAMUEL A. MAHOOD, associate professor of chemistry at Tulane University, the Squibbs Research fellow in organic chemistry. J. ALFRED HOFFMAN (Ph.D., University of Berlin, 1928) holds The Chemical Foundation, Inc., Research Fellowship and DONALD W. MACCORQUODALE, the Metz Research Fellowship. DR. FLORENCE E. HOOPER has been appointed research associate, National Tuberculosis Association.

Two new fellowships in chemistry have been established: the Fleischman Fellowship, a gift of the Fleischman Laboratories, and the Texas Oil Company Fellowship.

FOREIGN

Imperial College of Science and Technology, South Kensington, England. From a note in *The Chemical Age* it is learned that PROFESSOR K. FREUDENBERG, of the University of Heidelberg, a member of the staff of foreign editors of the JOURNAL OF CHEMICAL EDUCATION, was scheduled to deliver a course of lectures in chemistry at the Imperial College of Science and Technology on October 20th, 21st, and 22nd, dealing with the structure of cellulose and other polysaccharides, the constitution of lignine, and researches on the constitution of lignine.

St. Andrews University, Scotland. *The Chemical Age* states that payment has been made to this university of £3000 bequeathed by the late WILLIAM J. MATHESON, of Florida, for the institution of additional bursaries of chemistry scholarships at the United College.

University of Mexico. *See* **University of Texas,** p. 3015.

Institute of Physical and Chemical Research, Madrid, Spain. *Science* reports the announcement by the government of Spain that a building donated by the Rockefeller Foundation for an institute of physical and chemical research has been completed at Madrid. The Foundation gave $400,000 for the purpose. The Spanish government will support the institution.

Tokyo Imperial University, Japan. It has been announced in *Science* that PROFESSOR DR. KEIJIRO ASO, of the Tokyo Imperial University, a well-known agricultural chemist who was one of the early students of PROFESSOR OSCAR LOEW [see the JOURNAL OF CHEMICAL EDUCATION, 7, 314–5 (Feb., 1930)], will be a visitor to the United States this fall on his way back to Japan from attending the International Congress of Soil Science in Russia, to which he was an official delegate.

Diphenyl Derivative Proves Useful as Glue Preservative. The problem of glue preservation, both from the standpoint of preventing mold and the elimination of putrefaction, has been one of extreme importance to both glue manufacturers and glue users. Many substances have been used with more or less success and at a cost which has added greatly to the original price of the glue used. Beta naphthol, with a relatively high phenol coefficient, and thymol have undoubtedly received greater consideration over the past few years than most other chemical products.

During the past year there has been developed from the laboratory stage to actual commercial production a new product known as ortho-phenylphenol. Ortho-phenylphenol has a phenol coefficient of 38 in some organic solvents; however, this particular product is insoluble in water and, consequently, not suitable for incorporating in most glues. The sodium salt, which has a phenol coefficient of 21, is water soluble in all proportions and regardless of its high phenol coefficient is reported by bacteriological laboratories as being non-toxic to humans. The quantities necessary to use are exceptionally small, $^1/_2$ of 1% of sodium ortho-phenylphenate by dry weight has proved in all tests a complete control against both mold and putrefaction.

The measured strengths of glue in the maple block test have shown that in quantities from $^1/_{10}$ of 1% to as high as 5%, sodium ortho-phenylphenate has in all cases increased the strength of the glue and at the same time has given it a slightly bleached effect which is considered very desirable.

The cost of treating glue with sodium ortho-phenylphenate on the basis of $^1/_2$ of 1% is about one-half the cost of treating with beta naphthol and about $^1/_{10}$ of the cost of treating with thymol.

Recent Books

The Spirit of Chemistry. An Introduction to Chemistry for Students of the Liberal Arts. ALEXANDER FINDLAY, Professor of Chemistry, University of Aberdeen. Longmans, Green and Co., London, New York, Toronto, 1930. xvi + 480 pp. 88 figures, 62 portraits and illustrations. 21.5 × 14 cm. $3.00.

Those who read with pleasure and profit the author's earlier work, "Chemistry in the Service of Man," will find in the present volume even a greater treat. Professor Findlay refers to the former as "the first rough sketch of this work." "The Spirit of Chemistry" has more than twice the number of chapters present in the older volume, and it is much fuller in historical and biographical material. The number of figures, portraits, and illustrations has also been increased.

While the book remains unsurpassed in the richness of its historical and biographical features, it is somewhat disappointing in its presentation of industrial applications. The question of how much space should be devoted to industrial processes in a text for students of the liberal arts is one upon which there is no agreement today among educators, but surely such important industries as those manufacturing rayon, paper, and electric furnace products are deserving of more than one page each. And few American chemical engineers would allot twice the space to the manufacture of candles that is given to the carbonization of coal.

The theoretical treatment is so masterly that the reviewer for one is ruffled that the author did not treat some of the more recent advances. The classical laws of chemistry are developed fully and critically, and the illustrations and demonstrations of the same are aptly selected. The chapter on atomic structure closes, however, with scarcely a reference to the Bohr and Lewis models, and only a paragraph is given to the experimental work of the last five years on the wave properties of matter. The silence on the modern theories of solutions will also be disappointing to those who are dependent upon the genius of a man like Alexander Findlay to interpret for them the technicalities of modern science. Such topics would serve to show the liberal arts student that chemistry is a growing science theoretically as well as industrially, and that some of our most fundamental concepts are undergoing change.

JOHN R. SAMPEY
HOWARD COLLEGE
BIRMINGHAM, ALABAMA

The Science of Everyday Life. EDGAR F. VAN BUSKIRK, Head of the Department of Science, Stephens College, Columbia, Missouri; EDITH LILLIAN SMITH, Recently Instructor, Boston Teachers' College; and WALTER L. NOURSE, Vice Principal, John Burroughs Junior High School, Los Angeles. Revised edition. Houghton Mifflin Company, New York City, 1930. xvii + 620 pp. 297 figures. 19.5 × 14 cm. $1.60.

Several excellent general science textbooks have appeared within the last few years, emphasizing the fact that general science has come to occupy a place of permanence in the science sequence of secondary schools and that educators realize it fills a most vital need. More than twice as many students are enrolled in general science as in any other science. The present volume is a revision of a widely used textbook first appearing in 1919 and later revised in 1925. Two revisions of an originally meritorious textbook in a little more than ten years is indicative of the rapid changes occurring in science. A science textbook which is not revised every five or so years is practically out of date. The authors were formerly general science teachers, giving them a

background which is reflected in the practical nature characterizing the textbook. The introduction is written by Thomas H. Briggs of Teachers' College, Columbia University, who calls attention to the youth of general science, the hesitancy at first on the part of educators to accept it, and the philosophy and principles underlying the general science course.

The book represents a real revision of the previous edition both in subject matter and in organization. The questionable tendency of textbook writers to add additional pages to their revision has resulted in 115 pages being added to this book. In this case the addition seems justifiable as the new edition includes suggested lesson plans; a better mechanical organization of the book; a review outline for pupils; and a more complete list of suggested individual projects, reports, and reference books. The attractive cover, pictures, and illustrations represent an improvement over those of the previous edition. It seems to the reviewer that the reference book lists at the end of each chapter could be made more usable by including the price of the book listed and the location of the publishing firm.

The subject is organized into twenty-one chapters under five major topics of Air, Water, Food, Protection, and The Work of the World. As in the previous editions there are a series of projects and interesting experiments. Some experiments are to be performed by the classes as a whole, some by pupils working in groups, some individually, and some at home. Reading assignments are listed to be given out after the completion of the series of related problems. The authors recommend that class notebooks be kept by the pupils and a few rules for keeping notebooks are included. The keeping of a science scrap book is noted as a desirable type of pupil activity.

The subject matter seems to be well balanced, well organized, interestingly written, and sufficiently comprehensive. The topic "Weather" is included under the unit "Water and How We Use It" whereas more commonly it would have been included under the unit "The Air and How We Use It." The introduction to Part II discusses: Fundamental Conceptions in Science; The Universe; and Time and Space. Somehow, albeit it is well written and interesting, one gets the impression that these topics have been more or less thrown into a book in which the other parts bear a sequential relation to each other. The book has real merit as a science textbook and is deserving of being classed as one of the better books in a field which probably has the distinction of having the best secondary science textbooks.

C. M. PRUITT
UNIVERSITY OF ALABAMA
UNIVERSITY, ALABAMA

The Eighteenth Century Revolution in Science—the First Phase. ANDREW NORMAN MELDRUM, I.E.S., A.R.C.Sc., D.Sc. Longmans, Green and Co., Ltd., Basel Mission Press and Book Depot, Mangalore, India, 1929. vii + 60 pp. 16.5 × 24.8 cm. Paper binding. 4 s. 6 d. or Rs. 3/–, or $1.80.

"The book treats of Lavoisier's work during four years, 1772–75. It shows that Lavoisier, early in the year 1773, foretold a revolution in chemistry, even in science, and resolved to bring it about himself. From then until about the end of the year 1775 was his time of preparation for that revolution—the first phase.

"Lavoisier's indebtedness to his contemporaries and his attitude toward them, especially Baeyer and Priestley, have often been discussed. Having gone over the ground again with that advantage, I present fresh conclusions, along with the evidence on which they are based, for the consideration of those persons who are interested in the history of science."

The author has skilfully analyzed the literature in accomplishing his stated purposes. Lavoisier is given due credit, for example, "His work was inspired by a great motive and controlled by a prin-

ciple." That the author cannot justify the attitude of Lavoisier toward the work of Priestley is shown by such statements as "He was indebted to Priestley and would not admit his indebtedness." The book contains few errors. The student of this period of the history of chemistry will find the book to be of great assistance.

V. F. PAYNE

TRANSYLVANIA COLLEGE
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Science and the Scientific Mind. LEO E. SAIDLA, Assistant Professor of English, Polytechnic Institute of Brooklyn; and WARREN E. GIBBS, Instructor in English, Columbia University, and Lecturer in English, Polytechnic Institute of Brooklyn, Evening Division. First edition. McGraw-Hill Book Company, Inc., New York City and London, 1930. xiv + 506 pp. 13.8 × 20.3 cm. $3.00.

This book is a collection of twenty-four essays on science and the method of science, on science in the affairs of men's minds, on science in its relation—not here to the practical life of our times—but in its relation to the background of our thought, on science as the totality of our positive knowledge, our heritage from the past and our motive toward the future. Here is fine and thought-provoking writing: John Tyndall on "The Scientific Use of the Imagination," Thomas Henry Huxley on "Science and Culture," and Bertrand Russell on "The Place of Science in a Liberal Education." Every sincere student of the order of things is probably acquainted with some of the essays which are brought together in this volume. But it would be a rare library which would contain them all. And the present collection will interest any one, whether teacher or student, whether scientific investigator or not, who wishes for an insight into that part of science which transpires after the data have been collected.

The editors state in the preface that they have intended the book for a text to be used in connection with a course in advanced composition for students of science and technology. That being the case, it is natural that they should have chosen essays only by English-writing thinkers. A number of great men who have thought about the abstract relations of science are therefore not represented. The editors have chosen only recent pieces of writing. They ought to have included at least one of the essays of Charles Peirce. The reviewer wishes that something from early English writers had also been included, if only for the purpose of showing to students that profound thinking on the what and the whither of science did not first occur in the nineteenth century, selections from Francis Bacon and from Sir Thomas Browne, for example.

The twenty-four essays are grouped under the headings: I. Science; II. The Scientific Mind; III. Scientific Motive; IV. Science and Culture; V. Science and Civilization; and VI. Science and the Future. The following named authors are represented: ROBERT ANDREWS MILLIKAN (1 essay), FREDERICK BARRY (1 essay), JOHN TYNDALL (2 essays), EDWIN E. SLOSSON (1), J. W. N. SULLIVAN (3), THOMAS HENRY HUXLEY (2), WINTERTON C. CURTIS (2), ARTHUR SCHUSTER (1), HENRY FAIRFIELD OSBORN (1), TRUMAN L. KELLEY (1), NATHANIEL SHALER (1), FREDERICK SODDY (1), BERTRAND RUSSELL (1), J. W. MACKAIL (1), J. S. HALDANE (1), MICHAEL PUPIN (1), GEORGE E. WOODBERRY (1), THORSTEIN VEBLEN (1), and FREDERICK S. MARVIN (1). The book has four appendixes: *A*. Suggestions for the Study of the Structure of an Essay; *B*. Topics for Oral or Written Discussion and Reports; *C*. Reading List; and *D*. Biographical Notes.

This is a book to read and to possess, to put aside on the shelf—and to read again.

TENNEY L. DAVIS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

The Condensed Chemical Dictionary. Compiled and edited by the Editorial

Staff of the Chemical Engineering Catalog. Second edition revised and enlarged under the supervision of THOMAS C. GREGORY, *Editor*, and ISABELLE M. WELCH, *Assistant Editor*. The Chemical Catalog Company, New York City, 1930. 551 pp. 15.5 × 23 cm. $10.00 (buckram).

In this edition the authors have attempted not only to correct and enlarge the list of words found in the first edition, but to broaden the scope of the book so as to include processes of manufacture, physical and chemical properties, as well as to give additional uses and shipping regulations of the materials. There is no question but that they have succeeded admirably in these respects.

The reviewer recognizes that this book fills a definite need which no other book supplies so well. On the other hand it is not a chemical dictionary in the ordinary sense, and its title is misleading. If a chemist is to be considered a man back of a drug counter compounding remedies of all sorts, then this book is a chemical dictionary. Since the science has evolved from this stage the book should rather be entitled a glossary of pharmacological and chemical trade names. This assertion is supported by the fact that, of the 512 words listed on 20 pages chosen at random, only 182 were chemical compounds with definite composition.

In the "Dictionary" are described words like *alva marina, aralia, orchil, amber seed, angelica tree, axle grease, hydrargyri sulphas ethylenediaminata, sarsa parilla, bissabol, butea gum, chrysoprase, chittam bark*, etc. The book describes a few manufacturing processes such as the manufacture of glass, glue, soap, ink, etc., and includes full descriptions of the electroplating processes with cadmium, copper, chromium, nickel, tin, and zinc, but omits those of silver, gold, and platinum.

A large number of rather uncommon words such as *pyrocatecholcetodimethylaminophenyldimethypyrazolone* are found but many common ones like *dry ice, pectin, Duco, Selenese, Formica*, and *fluosilicic acid* are missing. Some descriptions are antiquated, such as the derivation of helium, and some formulas are erroneous, such as those ascribed to diamino diphenyl urea and phenyl propiolic acid. Both chloral and chloral hydrate are called trichloroacetic aldehyde.

In the Appendix will be found 46 tables of constants of various sorts, but these have no alphabetical arrangement.

Not only the tradesman and technologist but the teacher of chemistry will find this book a useful reference work.

C. A. JACOBSON
WEST VIRGINIA UNIVERSITY
MORGANTOWN, W. VA.

Popular Science Talks—Season of 1929. Volume VII. Presented by the Members of the Faculty of the Philadelphia College of Pharmacy and Science, edited by IVOR GRIFFITH. Philadelphia College of Pharmacy & Science, Philadelphia, Pa., 1930. 358 pp. 15.5 × 23 cm. $1.50.

"These lectures are given annually by members of the faculty of the college and cover a broad and interesting field of scientific subjects. They are not arranged in a course covering any particular field of science, nor is there any interdependence or connection. They are presented in a non-technical, easily understandable form, but without the sacrifice of scientific accuracy or completeness."

In "The Modern Sun Cult" by J. W. STURMER, there is discussed the absorption of ultra-violet light through glass, atmosphere, clothing, etc. The use of ultraviolet light as a tool by the chemist, as well as by the manufacturer of food products, in the irradiation of cereals, milk, and certain oils, is ably formulated.

The chapter by CHARLES H. LAWALL on "The Romance of Beverages" shows the part that liquid refreshments, alcoholic or otherwise, has played in the lives of people. The history of alcoholic drinks, tea, coffee, and cocoa is written in an interesting manner and includes many insertions of verse.

Probably the chapter written in the most scientific manner is the one by ARNO VIEHOEVER, on "Soil and Sod." Here are gathered data as to soils, and soil reactions. There is a catalog of common, wild, and tame house and drug plants, classified as to the pH of the soil best fitted for their growth. Here in less than 40 pages is an excellent introduction to agricultural chemistry, containing a wealth of material for the teacher or student.

The first half of IVOR GRIFFITH'S chapter on "The Cosmetic Urge" is "popular" in nature and, with apologies to Mencken, would be an excellent address to be made at a Rotary Club luncheon. The last half, however, contains information as to the composition of various cosmetics, and their value.

In "The Carbon Oxide Brothers, Mon and Di," F. P. STROUP discusses the manufacture and uses of these two substances.

The composition of modern fireworks is included in an article by E. FULLERTON COOK on "The History and Mystery of Pyrotechny." The use of military pyrotechnics is also briefly discussed.

"Iodized Salt—A Food or a Drug" is the title of an article by D. W. HORN which considers the problem from a clinical standpoint. The advantages and disadvantages are abundantly discussed.

Others chapters, not pertaining so directly to chemistry, are: "Time—What Keeps It?"; "How Much Do You Weigh?"; "Snakes and Snake Protection"; "Heart Beat and Blood Flow"; "Little Drops of Water"; and "Evolution of the Motion Picture."

Collectively they are an interesting series of articles, written in a popular style, although as would be expected, the style varies from article to article.

SAUL B. ARENSON
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CINCINNATI, OHIO

Sulfuric Acid and Its Manufacture. H. A. AUDEN, M.Sc., D.Sc. Longmans, Green and Co., London, New York City, 1930. vii + 231 pp. 50 figs. 14 × 22 cm. $6.00.

The author states that, in view of the size and inclusion of many details, the standard works on this subject are not suited to the student of applied chemistry. This book has as its purpose an exposition of the fundamental problems underlying the manufacture of sulfuric acid, and includes numerous references and a brief review of earlier methods and processes. Beginning with a chapter on history and statistics, the author devotes a chapter each to the properties of sulfuric acid, to its handling and transportation, and to the production from sulfates. Two chapters discuss the sources of raw material, sulfur and pyrites, and the burners used in making sulfur dioxide from them. The discussion of the lead chamber process and the purification and concentration of chamber acid occupies most of the rest of the book. The contact process and its control are covered in two chapters, a space which is not commensurate with the importance of contact acid manufacture. Some excellent tables of data are given, but more would have been welcome.

Most authors of books of this type greatly overestimate the preparation and background of the average student of applied chemistry, and take entirely too much for granted. While this book is very valuable to one who already has a very clear idea of the ways in which sulfuric acid is made commercially, it is doubtful whether a student trained solely in theoretical chemistry will be able to get anything like as much from the discussion as he would have if a few pages had been devoted to a simple, elementary summary by way of introduction and preparation. The illustrations are good, but are far too few in number. From the standpoint of educational value the book is so good that one cannot help regretting that it is not a little better so as to justify its being regarded as the last word in a brief text on this subject. The only way in which a book of this sort can be improved from an educational standpoint is for teachers to use it, and to tell the author in what respects they

feel it can be improved in the next edition.

W. T. READ
RUTGERS UNIVERSITY
NEW BRUNSWICK, N. J.

A Textbook of Organic Chemistry. A. F. HOLLEMAN, Ph.D., LL.D., D.Sc., F.R.S.E. Seventh English edition, John Wiley and Sons, Inc., New York City, 1930. xx + 594 pp. 80 figs. 15 × 23 cm. $3.50.

If popularity with students and teachers is to be accepted as a criterion of excellence in a textbook, Professor Holleman's treatise must be given a very high place indeed. For nearly thirty years it has been a favorite with classes in elementary organic chemistry throughout the world. During this time the book has appeared in nine different languages and the number of separate editions has mounted to the impressive total of fifty-two. Such wide and sustained popularity has rarely been enjoyed by any textbook.

The book was originally designed for use in the first course in organic chemistry. All important types of compounds were discussed though necessarily in a very brief way. Emphasis was laid on the theory underlying the subject and the number of facts given was kept down to a minimum. These features, now so amply justified by the success which the book has attained, have been retained in the present edition.

Many alterations are to be found in the text of this edition. The application in organic chemistry of certain physiochemical methods has been given a fuller treatment. Important changes are to be found in the discussion of such subjects as disaccharides, enzymes, and the relationship between color and constitution. Minor changes throughout the book serve to bring it up to date on many points of theory and practice which have undergone change during the last few years.

Excellent as the book is, the reviewer feels that in certain respects it fails to reflect fully the spirit of present-day organic chemistry. For example, emphasis is everywhere placed on those reactions which are supposed to indicate structure rather than those which are useful in synthetic work. Thus the Wurtz-Fittig method is cited as frequently as the Grignard reaction, the Friedel-Crafts method, or the use of malonic ester, despite the fact that the first-mentioned type of reaction is comparatively of little use in synthetic work and of doubtful value in structural studies.

Thiele's theory of partial valencies (page 367) has not proved of sufficiently general use to warrant its inclusion here except possibly as a historical note. It would seem advisable rather to include some mention of the newer developments in valence theory at least to the extent of showing that all valencies are not alike in character.

The modern tendency to regard aromatic chemistry as a special case of ethylenic chemistry is not found in the book. For example, on page 357 aromatic compounds are contrasted with saturated aliphatic compounds, whereas one would expect them to be compared with ethylenic compounds. The chemistry of phenols is compared with that of alcohols, but enols are not mentioned in this connection. Again, the treatment of cyclohexane derivatives as hydroaromatic compounds relates them to benzene. Would it not be better to compare them with the paraffins? Similarly, would it not be more helpful to compare the terpenes with the pentenes with which they are so closely allied?

Apart from such considerations as these, this new edition of the book fully merits a continuation of the wide popularity enjoyed by the preceding issues.

REYNOLD C. FUSON
UNIVERSITY OF ILLINOIS
URBANA, ILL.

An Introduction to Organic Chemistry. ERIC JOHN HOLMYARD, M.A., M.Sc., D.Litt., F.I.C., Head of the Science Department, Clifton College. Edward Arnold & Co., London; Longmans, Green and Co., New York City, 1930. xi + 282 pp. 31 figs., 9 plates. $1.75.

This book, which is based upon the author's "Outlines of Organic Chemistry," is intended, according to the preface, for complete beginners, boys and girls, who have just passed the school certificate examination in England. "The number of compounds described has deliberately been kept small" in order that the instructor may "make haste slowly" and "allow the elementary work to be thoroughly assimilated."

Within the limits established, this text is an excellent piece of work. The organization of the material is worthy of note. Especially commendable too is the emphasis put on structure in Chapter III. Here with painstaking detail the author discloses the methods for determining the arrangements of the atoms in alcohol, formaldehyde, acetaldehyde, formic acid, and ethyl formate. The discussion of the two series, aliphatic and aromatic, begins in each case with the hydrocarbons and continues through the derivatives. The plan, in general, seems to be to discuss the most typical member of a homologous series in some detail, after which a general discussion of the series as a whole follows.

The few number of compounds discussed will undoubtedly result in adverse criticism from some quarters. Of the sixty-five common organic substances listed at the beginning, approximately twenty per cent receive no further mention. For instance, there is no discussion of the alkaloids, the organo-metallo compounds, the heterocyclic compounds, the carbocyclic compounds other than those of the aromatic series, and many other types frequently met in elementary organic texts. In other words the author attempts nothing but a discussion of the simpler types of the aliphatic and aromatic series, a method which cannot by its very nature consider some very interesting compounds of great practical importance. In the opinion of the reviewer this is not a serious objection. The author aims at thoroughness which is to be followed by a more advanced study later.

Several of the new features introduced in recent American texts are noticeably lacking in this work. The Geneva system of nomenclature is completely ignored; even the names methanol and ethanol, which have come to be quite common in America, are not mentioned. The electron and the part which it presumably plays in organic combinations have likewise been omitted.

The book is remarkably free from errors. To be sure the statement in regard to phenol—"an ample supply of which is always available from coal tar"—is not true, at least, in America. In the discussion of the sugars clarity might be introduced by giving the ring formulas for some of the hexoses since these are later used in the structural formulas for sucrose and lactose.

The distinctness of the type, together with the spacing arrangement of the equations, makes reading easy. The plates add a great deal to the attractiveness of this work. For the student who desires a limited treatment of the subject this text offers a clear, well-arranged, presentation.

C. A. BUEHLER
UNIVERSITY OF TENNESSEE
KNOXVILLE, TENN.

Dietetics and Nutrition. MAUDE A. PERRY, B.S., formerly Director of Dietetics at the Michael Reese Hospital, Chicago, Illinois, and at the Montreal General Hospital, Montreal, Canada. C. V. Mosby Co., St. Louis, Missouri, 1930. 332 pp. 13.5 × 19.5 cm. $2.50.

The purpose of the book, as stated by the author in the preface, "is to present *scientific* and *technical* material in plain and simple language, to meet the needs of schools, training schools for nurses, graduate nurses, physicians, teachers, and all others interested in personal and public health problems."

The author has fulfilled the aim in that the information, as presented, is stated in simple language, making the material readily available for any reader. An excellent feature is a short outline preceding

each chapter, setting forth the high points of the ground covered by that chapter.

The first two chapters discuss food and its relation to the normal diet and the factors which affect food requirement. Foods and their particular characteristics are discussed according to the following chapter headings: Nitrogenous Foods, Non-Nitrogenous Foods (Carbohydrates), Non-Nitrogenous Foods (Fats and Oils), Water and Beverages, Mineral Salts, Vitamins, Food Adjuncts, Care, Preservation, and Cooking of Foods.

The Chemistry of Nutrition is covered in two chapters, namely, Nutrition and Metabolism. The next few chapters deal with the food requirements at certain age levels.

The remainder of the book, which is the major part of it, deals with diet in disease. These chapters on dietary treatment, in which she has very carefully presented the various dietary practices, show a wide experience and knowledge in this field on the part of the author. Earlier in the book, there are a number of statements of a scientific nature which seem rather ambiguous. These no doubt could have been avoided by a more careful editing.

Footnotes, or a bibliography, giving the complete names of the authors and investigators quoted by Miss Perry would have been helpful.

CLAIRABEL P. WELSH
M. MARIE MOUNT

UNIVERSITY OF MARYLAND
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A Textbook of Dairy Chemistry. EDGAR R. LING, M.Sc. (Lond.), A.R.C.Sc., F.I.C., Lecturer in Agricultural Chemistry at the Midland Agricultural College, and Official Deputy Agricultural Analyst for the Lindsey Division of Lincolnshire, England. John Wiley & Sons, Inc., New York City, 1930. vii + 213 pp. 12 × 18.5 cm. $2.25.

This textbook of "Dairy Chemistry" is written to meet the requirements of students in dairying and others who have some knowledge of chemistry, but who do not have the time or inclination to go deeply into the technical phases of the subject, yet who seek an insight into the constitution, composition, and methods of analysis of milk and other dairy products.

About one-third of the text is devoted to a brief discussion of the chemical nature of the several constituents of milk, some of their "characteristic" qualities, the extent to which they are present, and the influence of various factors in affecting the composition of milk and its constituent parts. The detection of adulteration in milk, through a determination of the freezing point or the refractive index of the milk serum, is lightly touched upon.

A few pages are allotted to brief statements respecting the method of processing and the composition of such milk products as condensed milk, milk powders, cream, and ice cream. The composition of butter, together with the application of chemical means for the detection of adulteration and of butter substitutes is touched upon. Some space is also devoted to the action of rennin upon milk and to the chemical changes involved in the ripening of cheese and the development of flavor.

Changes in milk caused by the application of heat and the action of milk upon certain metals receives brief, but concise attention. Specific directions are contained for the separation and examination of the major constituents present in milk.

Special emphasis is given to the analysis of milk, particularly to the Gerber, the Adams, and the Rose-Gottlieb methods for the determination of milk fat, and the Kjeldahl and aldehyde figure methods of estimating protein. Means of determining the specific gravity of milk, the acidity of milk, the detection of the presence of preservatives in milk, and the determination of the freezing point of milk are indicated and explained. Directions for the sampling and analysis of cream, butter, and cheese are given some consideration.

The book is a source of valuable information with reference to the chemistry

of milk and milk products, presented in a manner primarily of interest to those who desire a knowledge of the application of chemistry to the dairy industry, either as a source of general knowledge or as an elementary treatise introductory to a more exhaustive and technical study of the subject.

DEVOE MEADE

AGRICULTURAL EXP. STA. &
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1000 and One. The Blue Book of Non-Theatrical Films. Editors, NELSON L. GREENE, *Chairman*, EVELYN T. BAKER, JOSEPHINE F. HOFFMAN, F. DEAN MCCLUSKY, STELLA EVELYN MYERS, and MARGUERITE ORNDORFF. The Educational Screen, Inc., 5 South Wabash Ave., Chicago, Ill., Sept., 1930. 144 pp. 11 × 18.5 cm. Free to subscribers of *The Educational Screen*, $0.75 to the general public.

The non-theatrical films, both 16- and 35-mm., contained in this list are arranged according to a classified subject index. Information concerning the title, number of reels, brief review and comment, name of distributor, and size are given for each film.

M. W. G.

BULLETINS

Research for Industry. Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio, 1930. 31 pages. Illustrated. 18.5 × 26.5 cm.

This booklet is issued to describe the facilities for research service to industry available at Battelle Memorial Institute. The booklet is intended for distribution primarily to industrial executives and research directors.

National Ministries of Education. JAMES F. ABEL, chief, Division of Foreign School Systems, Office of Education. U. S. Dept. of the Interior, *Bulletin* **No. 12,** 1930. U. S. Govt. Printing Office, Washington, D. C. (For sale by Superintendent of Documents.) 158 pp. 15 × 23 cm. $0.25.

Contains a survey of ministries of education in other countries and a bibliography. Provides real data for those who care to study seriously the place of educational administration in our (U. S.) scheme of government.

National Advisory Council on School Building Problems. Its Organization, Purposes, and Methods. ALICE BARROWS, Specialist in School Building Problems, Office of Education. U. S. Dept. of the Interior, *Pamphlet* **No. 7,** July, 1930. U. S. Government Printing Office, Washington, D. C. (For sale by Superintendent of Documents.) 28 pp. 15 × 23 cm. $0.05.

Awards of Royal Society. His Majesty the King has approved of the following awards this year by the president and council of the Royal Society in respect of the two Royal medals: a Royal medal to PROF. J. E. LITTLEWOOD for his work on mathematical analysis and the theory of prime numbers. A Royal medal to PROF. R. MUIR for his contributions to the science of immunology. The following awards have also been made by the president and council: The Copley medal to PROF. MAX PLANCK, of the University of Berlin, for his contributions to theoretical physics and especially as the originator of the quantum theory. The Davy medal to PROF. G. N. LEWIS, of the University of California, for his contributions to classical thermodynamics and the theory of valency. The Hughes medal to PROF. HANS GEIGER, of the University of Kiel, for his invention and development of methods of counting alpha and beta particles. —*Nature*

ANNUAL INDEX—JOURNAL OF CHEMICAL EDUCATION

Volume 7, 1930

To facilitate the use of this index a few explanatory remarks are offered. (See also pp. 2765–6.) Both author and subject indexes of the material appearing in the JOURNAL OF CHEMICAL EDUCATION during the year 1930 have been compiled.

AUTHOR INDEX

The author index consists of five parts as follows:

Articles
Correspondence
Abstracts
The Library, Sept., 1929–June, 1930
Books Reviewed

Under each of the five headings, which appear in the above order, the authors' names are listed alphabetically. In instances of joint authorship, each author's name may be found in its own alphabetical position. Following the author's name may be found the title of the article and the page reference. If the same author has contributed more than one article, the author's name appears only once, and all the titles are listed alphabetically under it.

SUBJECT INDEX

The subject index consists of ten parts as follows:

Articles
The Chemistry Student
Abstracts
The Library, Sept., 1929–June, 1930
Books Reviewed
Chemical Digests
Correspondence
Editor's Outlook
Frontispieces
Science Service Notes and Other Scientific News

Under each of the ten headings, which are arranged in the above order, all titles are listed alphabetically. In the alphabetical arrangement that part of the title before the comma has been given precedence. For example, the order for the following items is:

Aluminum, The Story of—
Aluminum Chloride, The Manufacture of Commerical Anhydrous—

In cases of hyphenated words, the hyphen has been ignored for purposes of alphabetical arrangement and the word considered as a single one.

The subject indexes for the **Abstracts** and for the **Books Reviewed** are classified under headings as follows:

Abstracts:
- **Apparatus, Laboratory Practice, and Demonstrations**
- **Teaching Objectives, Methods, and Suggestions**
- **Administrative Problems and Devices; Curricula**
- **Keeping Up with Chemistry**
- **Scientific Reviews and Bibliographies**
- **Historical and Biographical**
- **Educational Measurements and Data**
- **The Philosophy of Education**
- **The Philosophy of Science**
- **Professional**
- **Contemporary News and Comments in Chemistry and Education**
- **Foreign Chemical and Educational Conditions**
- **General**

Books Reviewed:
- **Books**
- **Miscellaneous Publications**

The titles under each of these headings are arranged alphabetically, and some titles have been cross-indexed and may be found under several of the headings.

In general, significant words in titles have been indexed, many titles thus appearing several times. For those titles which did not lend themselves easily to this treatment, there have been inserted (in italics) topics which will enable the reader to find such material more easily. See, for example, under **Articles:**

Antimony—See Questions for the Student of Elementary Chemistry

In the case of historical articles, in which the lives and contributions of several scientists are discussed, the separate names, as well as the title, have been indexed. For example:

Black, Joseph—See Scotland's Contribution to Chemistry

Furthermore, such topics as (1) *Apparatus*, (2) *Demonstrations*, (3) *Projects*, etc., have been inserted (in italics) and abbreviated titles, with page references of all articles pertaining to each, have been listed under the proper headings. Titles of articles appearing in the **Chemical Digest, The Chemistry Student, Correspondence,** and **Frontispieces** appear in the Article Index as well as in the separate indexes for these various sections of the JOURNAL. The titles of the headings of the various subject indexes, as well as the titles of the classification headings of the abstract subject index, have been inserted (in italics) with page references in the Article Subject Index.

The subject index for **The Library** covers items appearing from September, 1929, to June, 1930, these issues covering the entire period during which **The Library** was published in the JOURNAL. (It is being continued in *The Chemistry Leaflet.*)

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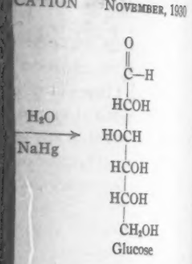
TABLE I

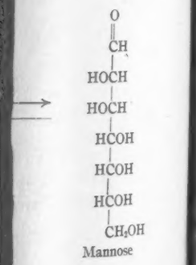
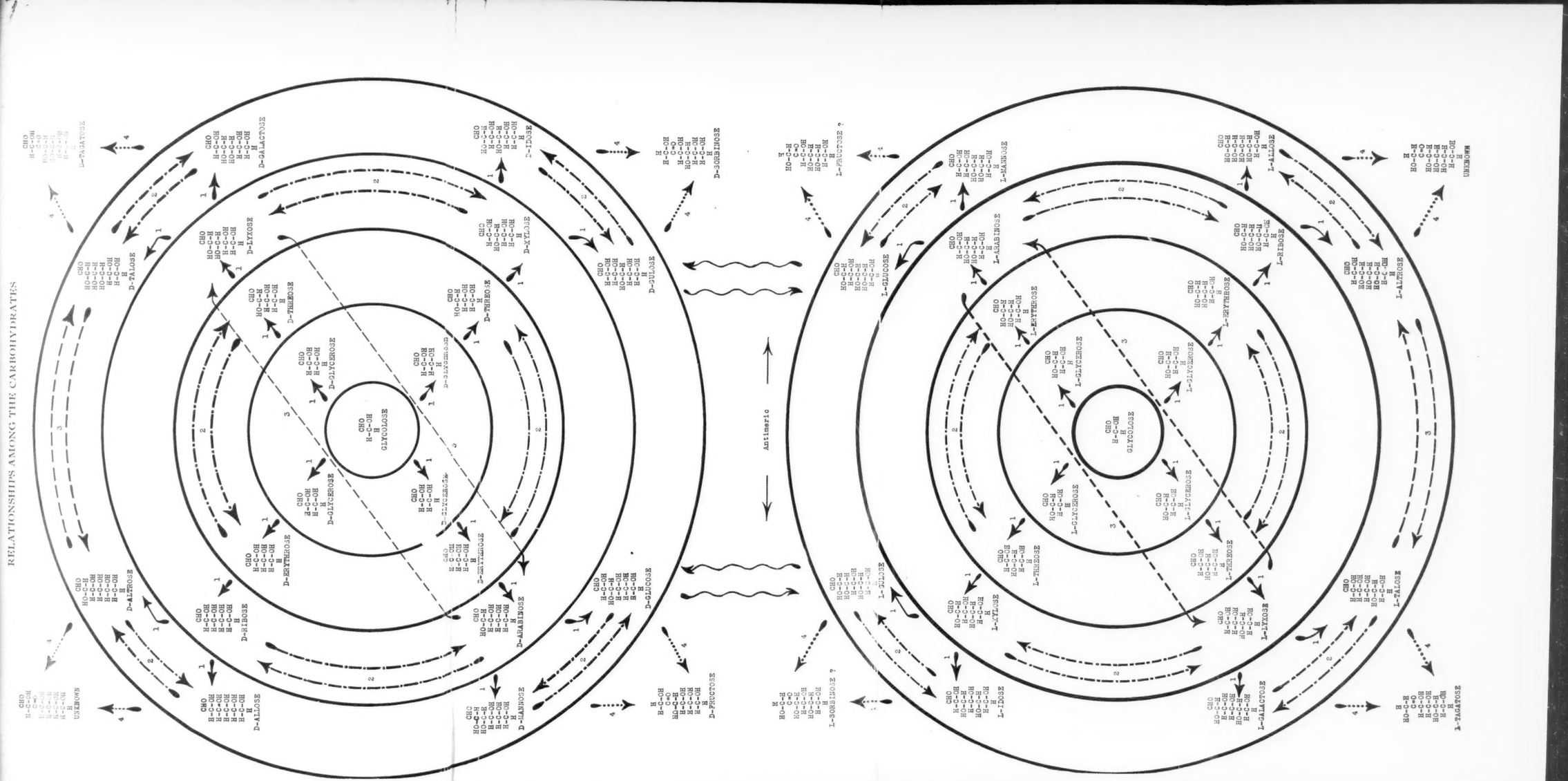
Number of Graduate Students Engaged in Research in Chemistry According to University and Subject

"M" indicates those working for a Master's degree, "D," Doctor's degree, and "F," number on faculty engaged in research

Universities by State	General and Physical M D F	Colloids M D F	Catalysis M D F	Subatomic and Radio M D F	Electro-Inorganic M D F	Electro-Organic M D F	Photochemistry and Photography M D F	Inorganic M D F	Analytical M D F	Metallurgical M D F	Organic M D F	Physiological M D F	Physicological-Chemical M D F	Pharmaceutical M D F	Sanitary M D F	Nutrition M D F	Foods M D F	Agricultural M D F	Industrial M D F	Chemical Engineering M D F	TOTAL M D F	Universities by State
Alabama:																						*Alabama:*
Howard College																					5	Howard College
University of Alabama	2		2				1	1	1 1		5 1 2	2				2			1 1	2	15 9	University of Alabama
Arizona:																						*Arizona:*
University of Arizona	1 1								1 1		2	2						1 5			7 1 8	Univ. of Arizona
Arkansas:																						*Arkansas:*
University of Arkansas															2 1	4		2	3		6 12	University of Arkansas
California:																						*California:*
California Inst. Tech.	1 8 6			4 2		1	1 5 2		1 1		1 5 4 2 3	1 1 1 2								5 1	8 18 15	California Inst. Tech.
Stanford University	7 4 7	2 5 2		2 1 1			1 3 1		1		8	4 2					2 2		1 2		23 24 18	Stanford University
Colorado:																						*Colorado:*
Colorado College	1								1		1										2	Colorado College
University of Colorado	3 1 1						1	4 1			3 1 2	9 1 3	2		3 3 1						22 6 10	University of Colorado
Connecticut:																						*Connecticut:*
Connecticut Agr. College		1							2		1										3	Connecticut Agr. College
Trinity College	2	2						1			3 1										3 3	Trinity College
Wesleyan College	1	1					2		1		1								2 1		7 3	Wesleyan College
Yale University	8	9	5 2								21 6									1 5 4	1 39 24	Yale University
Delaware:																						*Delaware:*
University of Delaware											1 1							4		1	1 6	University of Delaware
District of Columbia:																						*District of Columbia:*
American University		1									2 1 1										2	American University
Catholic University		1							2		7 3 3	2 1 3									2 2 1	Catholic University
George Washington University	2	2							2		3 3	1 3	7								13 6 9	Geo. Washington Univ.
Georgetown University														2							2 4 15	Georgetown University
Florida:																						*Florida:*
University of Florida	1 2							1 1	2 2		3 2			2				1	1 1	2 1	12 12	University of Florida
Georgia:																						*Georgia:*
Wesleyan College	1	1																			2	Wesleyan College
Hawaii:																						*Hawaii:*
University of Hawaii	1										3 2	1				1	1	4			3 5	University of Hawaii
Idaho:																						*Idaho:*
University of Idaho	1 1	1							2	2 1	1 1					1		4	1		5 11	University of Idaho
Illinois:																						*Illinois:*
Illinois Wesleyan	1										1										2	Illinois Wesleyan
Monmouth College			1																		2	Monmouth College
Northwestern University	2 3 4										4 12 6 7 36 8	9 4 1 1 17 7 6 2 2	2 2			2 7 1 2 1	6 1 1 1 1				25 87 29	University of Chicago
University of Chicago	3 7 3	1 6 1		1 1			3 6 5	2 6 2	1 4 5		18 37 9			1	1 5 4				1	2 6 10	44 86 50	University of Illinois
University of Illinois	8 22 5	1 4 5			1	1		3 5 5		1												
Indiana:																						*Indiana:*
Indiana University	2 2	1	1 2		3 2	1 1		4 1 1	1 1 2 2	1	7 2 2	2 1				1				2	22 9 7	Indiana University
Purdue University	2 3 3							4 1 2			11 4 2	8 3 1								2 2	28 13 12	Purdue University
Rose Polytechnic Institute	1		1								1										3	Rose Polytech. Institute
University of Notre Dame	4		1						5 1	1 3 1	2 4 1										12 7 4	Univ. of Notre Dame
Iowa:																						*Iowa:*
Grinnell College																					1	Grinnell College
Iowa State College	7 1	3 4 1						5 5 2			6 15 1	2 10 1				3 8 3	1 7 1	8 12 5		3 5 3	31 73 18	Iowa State College
State University of Iowa	1 4 1	2 1	1			3		2 2 3	4 3 1	1	7 12 2	6 4 5	7 1	3	3 2 2	8 2				4 3 1	35 42 23	State Univ. of Iowa
University of Dubuque																	1				1	Univ. of Dubuque
Kansas:																						*Kansas:*
Kansas Agricultural College	4 1 3	1							1		2 2	3 1 1				1 1	1	5		1	8 5 16	Kansas Agr. Coilege
University of Kansas	1 1	4 3			1						7 2										14 6	University of Kansas
Kentucky:																						*Kentucky:*
University of Louisville	1					1			1		4 1	2 1				1 2			1	5	13 7	University of Louisville
Louisiana:																						*Louisiana:*
Louisiana State University			1			1 1			1 1		4 2	2						4 1	3 2	2 1	15 9	Louisiana State University
Tulane									1		2										3	Tulane
Maine:																						*Maine:*
Bates College											1 1 2										1	Bates College
University of Maine	1		1		1	1		1			1 2								1	1	2 7	University of Maine
Maryland:																						*Maryland:*
Johns Hopkins University	12 8	3 4	3	1 1		3	1		1		4 12 6	1 3				6 5				3 5	4 42 36	Johns Hopkins Univ.
University of Maryland	2 2	1						1 1	1		8 2					1		2 1 2			13 3 10	University of Maryland
Massachusetts:																						*Massachusetts:*
Amherst College		1							1		1 1										3	Amherst College
Boston College	3 1								1		1 1										4 2	Boston College
Clark University	1								1		4 1										4 3	Clark University
Harvard University	13 11				7		2				25 14	1 1							1		49 26	Harvard University
Holy Cross College	3 1								1	1 1	2 1										6 4	Holy Cross College
Massachusetts Agr. College	1 1								1		1 2	1 1						1			4 5	Massachusetts Agr. Coll.
Massachusetts Coll. Pharm.														3 2							3 2	Massachusetts Coll. Pharm.
Massachusetts Inst. Tech.	1 11 8							1 3 3	2		6 21 9	1					2		2	65 21 20	73 56 47	Massachusetts Inst. Tech.
Mt. Holyoke College	4 2										1 1										5 3	Mt. Holyoke College
Smith College	1 1	1							1		2 1	1 1									4 5	Smith College
Tufts College	1 1									1	1								1		1 4	Tufts College
Wellesley College											1 1	2									1 3	Wellesley College
Williams College	2 2							1			1 2										2 4	Williams College
Worcester Polytech.	1				1						2				1					3 1	3 6	Worcester Polytech.
Michigan:																						*Michigan:*
Michigan State College	5 2 2				1				1 1	2 1	3 1	2 1			1	1	2	3	1		17 2 11	Michigan State College
University of Michigan	14 10 3				5 1				7 4		5 5	6 5 5		6 2						24 20 13	44 58 33	University of Michigan
Minnesota:																						*Minnesota:*
University of Minnesota	1 10 4	5 2				1 1 1		3 2 3	1 4		2 3 3	4 6 3				4 1 2		1 2 5	3 1 2	5 2 2	24 34 31	University of Minnesota
Mississippi:																						*Mississippi:*
University of Mississippi	1 1								1		1 1	1									2 4	University of Mississippi
Missouri:																						*Missouri:*
Missouri School of Mines	1							1 1 1	1 1	3 2	1 1										6 1 6	Missouri School of Mines
St. Louis University	6 2							1			2 1	1 5 2									9 5 6	St. Louis University
University of Missouri	1 1			5 1 2					1		3 3					1 3 2			1 1	1 1	18 5 10	University of Missouri
Washington University	2 1 4								1		4 2 3	1 1 9	1							1 1	8 4 19	Washington University
Nebraska:																						*Nebraska:*
University of Nebraska	3 2 4								1 1		12 10 3	5 2				1	2	4 5	1		25 12 19	University of Nebraska
Nevada:																						*Nevada:*
University of Nevada								1 1		1	1 2							1			3 4	University of Nevada
New Hampshire:																						*New Hampshire:*
Dartmouth College											2										2	Dartmouth College
New Jersey:																						*New Jersey:*
Princeton University	12 2 9		2 2 5		1		1 2 3	2		3	8 4									1	23 6 26	Princeton University
Rutgers University	3 1 1	2 2							2 1 2		1	1 2			3 3	1 3 2		1 7 9			13 15 21	Rutgers University
New Mexico:																						*New Mexico:*
College of Agriculture																1		3			4	College of Agriculture
New York:																						*New York:*
Albany Medical College																					2	Albany Medical College
Columbia University	16 7	7 2		2 1			1	2 5	7 4		32 8	9 6				14 7				23 24 7	23 113 48	Columbia University
Cornell University	5 28 5							2 7 3	1 2		18 29 2			1 1 1				2 1	6 8 1		33 66 15	Cornell University
Fordham University											6 13 1	4 9 2									10 22 3	Fordham University
N. Y. State Coll. Forestry											1							1			1 2	N. Y. State Coll. Forestry
New York University	5 11 8	1					5 5 2		4 2		16 7 8	3 1 3								2 1	35 25 26	New York University
Rensselaer Polytechnic Inst.	2 1 1			2 2					1	1 2	1 2 1									1	6 5 6	Rensselaer Polytechnic Inst.
Syracuse University	2 2 1							2 1	1 1		3 1 2									1	8 3 9	Syracuse University
Union College	1 2								1	2 1											1 2	Union College
University of Rochester	2 1 2										3 2 2	5 4									5 8 8	University of Rochester
Vassar College					1 2						2										1 4	Vassar College
North Carolina:																						*North Carolina:*
Duke University	3 3 2								1		3 3 2							4			6 6 8	Duke University
N. C. State College	1 2 3							1 1	2 1		5 2 2							2 1	1 1		4 2 11 8	N. C. State College
University of North Carolina																			5 1 1			University of N. C.
North Dakota:																						*North Dakota:*
North Dakota Agr. College								1			1										1 2	North Dakota Agri. College
Ohio:																						*Ohio:*
Case School											1 1								1	1	3	Case School
Kenyon College	1										1										2	Kenyon College
Oberlin College	3	1 2 1									1										3 7	Oberlin College
Ohio State University	5 12 1	1 1						2 4 3	3 4 2	3 1 2	7 15 4	6 2 4						7 4 3	9 14 6		43 55 25	Ohio State University
University of Akron											4								2		2 2	University of Akron
University of Cincinnati	6 4 3								1 2 1		2 4	1 1								3 2	12 10 10	University of Cincinnati
University of Dayton	1	1				1 1															3 1 3	University of Dayton
Western Reserve	3 1	1 1	1 2 2 1						1 1		2 1	1 4 6									15 10 13	Western Reserve
Wittenberg College								5 3 3			3 1 1										1	Wittenberg College
Oklahoma:									1													*Oklahoma:*
Agr. and Mech. College	1 1											1 3				2		2	1 1	1 2	6 9	Agr. and Mech. College
Oregon:																						*Oregon:*
University of Oregon	2	1 1							1		2 1					2					5 5	University of Oregon
Pennsylvania:																						*Pennsylvania:*
Bryn Mawr College	2											1									4	Bryn Mawr College
Bucknell University									1		1 1									1 1	2 2	Bucknell University
Carnegie Institute Technology	3									5	2										5 5	Carnegie Institute Tech.
Dickinson College	1								1												1	Dickinson College
Grove City College	1 2																				2	Grove City College
Haverford College									1												2	Haverford College
Lafayette College	2 3								1												1	Lafayette College
Lehigh University	3 2	2 1	1		2						3 2 3						1	2 3	6 1 4	2 3 3	2 3	Lehigh University
Pennsylvania State College	3 8 1	5 1 1		1				1	1	2 3 2	2 15 9					3 2 3		1 2 2			18 24 33	Pennsylvania State College
Swarthmore College								2 3 4	2		2	6 1							1 4	3 4	24	Swarthmore College
University of Pennsylvania	2 5	2 5	2 1		2	1 2			1 4		1 7 1	1 5 12	8		2 1	2	6 1	2	4 1	2 4 2	12 39	University of Pennsylvania
University of Pittsburgh	4		2		1	4 1		1 3	1 1	1 1	2 1	1 1 12									7 39 15	University of Pittsburgh
Washington & Jefferson	1										1										2 2	Washington & Jefferson
Rhode Island:																						*Rhode Island:*
Brown University	3 2	1	1 1		1		1	4 2 2	1		5 4 3										11 9 12	Brown University
South Dakota:																						*South Dakota:*
S. D. State Coll. A. and M.									1 1		1										2 1	S. D. State Coll. A. and M.
S. D. State School of Mines												3 1									3 1	S. D. State School of Mines
University of South Dakota	1		1						1		1 1						1				2 6	University of S. Dakota
Tennessee:																						*Tennessee:*
University of Tennessee	2	1									4 2	1 2 3									7 2 6	University of Tennessee
Vanderbilt University	1				1 1			1 1 1	1 1	1 1	2 1	3	2 6		1			2 1 1			10 2 17	Vanderbilt University
Texas:																						*Texas:*
A. and M. College																					6	A. and M. College
Baylor University	1	1						2			1 1										2 2	Baylor University
Rice Institute	1 2 1								1		10 1 3			1 1 1		2			1	1	5 2 6	Rice Institute
University of Texas	5 1	3 1										1								12 1	28 1 9	University of Texas
Utah:																						*Utah:*
University of Utah	2 1		1					1 1	1 1	6 4	2 1							1			12 9	University of Utah
Utah Agricultural College		1 1							1		1 1					1 1					3 5	Utah Agricultural College
Vermont:																						*Vermont:*
Middlebury College											4 1	2									6 2	Middlebury College
University of Vermont	2 2						2 1				1 1						1 1				4 6	University of Vermont
Virginia:																						*Virginia:*
Roanoke College																					1	Roanoke College
University of Virginia	5 2		2 1				1		1		8 6	1 1	1 1					3		1	1 17 14	University of Virginia
Virginia Polytechnic Institute								1	1 1 1	1	1				1 1				1	1	5 10	Virginia Polytechnic Inst.
Washington and Lee							1		2												3	Washington and Lee
Washington:																						*Washington:*
State College	3 2 2		1			1					2 2	1 1 1				1		3 5		1 2 2	9 3 13	State College
University of Washington	5 2 2							1	5 2 2		5 2 2			2 1							17 9 10	University of Washington
Wisconsin:																						*Wisconsin:*
Marquette Medical												2 3									2	Marquette Medical
University of Wisconsin	10 12 7	2 7 3	3 1	1	1 1		2 1	4 4 2	2 2		11 23 11	3 2	4 4 2	5 9 3		4 1		9 16 16	2 3 3	2 2 5	58 91 59	University of Wisconsin
Wyoming:																						*Wyoming:*
University of Wyoming	1										1 2	1	1					1			1 7	University of Wyoming
TOTALS	194 254 227	33 49 41	9 25 19	10 10 15	9 15 11	5 10 12	15 26 21	60 56 69	54 41 82	25 11 26	314 405 250	113 109 146	8 6 31	12 15 20	16 11 17	33 47 44	11 20 18	42 49 94	54 37 45	183 102 103	1210 1303 1291	



iliana (*4*) reaction (arrow
e a specific example. If
is formed which may be
acid tends to lose water
sodium amalgam to glu-
s of 1. In passing from
enstein is employed (*5*).
th various alkalis where-
is produced which rear-
ptical isomer of glucose.
e desired hexose may be
ones.



aldehyde group for the
d-altrose and *d*-talose,
s loses water to produce
he mono-basic acid of
the amyl-oxide ring of
but exists probably in